THE ONTARIO ASSESSMENT INSTRUMENT POOL

PHYSICS

SENIOR DIVISION

1981

Ministry of Education
Ontario

Hon. Bette Stephenson, M.D., Minister
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PHYSICS

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ISBN 0-7743-6698-2
ISSN 0228-0957
ON 01650

This package contains assessment materials relating to the aims, goals, and objectives of Senior Division Physics as implied in the Ontario Ministry of Education guidelines, Curriculum S-17A (1966) Physics Senior Division Grade 11 and Curriculum S.17C (1967) Physics Grade 13. Additional materials will be distributed as they become available.

Cost: $15.00

Copies of this package may be obtained from:

	(mail orders)
Ontario Government Bookstore	Publications Centre
880 Bay Street	880 Bay Street, 5th Floor
Toronto, Ontario	Toronto, Ontario
M7A 1N8	M7A 1N8

(Cheques should be made payable to the Treasurer of Ontario.)

or

Publications Sales
The Ontario Institute for Studies in Education
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(Cheques should be made payable to OISE.)

1981

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ONTARIO ASSESSMENT INSTRUMENT POOL
PHYSICS - SENIOR DIVISION

Introduction

The purpose of this Ontario Assessment Instrument Pool is to provide a variety of assessment instruments designed to meet the aims, goals, and objectives of Senior Division Physics as stated or implied in the Ontario Ministry of Education Curriculum guidelines: Curriculum S-17A (1966) Physics Senior Division Grade 11 and Curriculum S.17C (1967) Physics Grade 13.

Some of the instruments published in this first package were collected and/or developed by the Science Teachers' Association of Ontario (STAO) under a contract awarded by the Ministry of Education. Other instruments were developed by the Department of Measurement and Evaluation of the Ontario Institute for Studies in Education, under an earlier contract awarded by the Ministry of Education. The latter formed part of the Ontario Physics Achievement Tests administered to students throughout the Province of Ontario in April of 1967, 1968, 1969, and 1970.

The ultimate aim of this Pool is to put into the hands of physics teachers a resource containing a variety of assessment instruments. However, this first package contains only multiple choice instruments. Other kinds of instruments will be included in subsequent supplemental packages.

Background information about the creation of the Ontario Assessment Instrument Pool (OAIP), as well as information about other programs and courses for which assessment instruments have been developed, may be found in the Ministry's publication Ontario Assessment Instrument Pool: A General Introduction (1980).

Variety of Assessment Instruments

As used here, the term assessment instrument refers to the

smallest unit of the Physics Pool which can be used by teachers to evaluate students' achievement of a specific objective. The objectives of physics are many and varied. Some objectives specify the knowledge component of physics, others the processes of scientific inquiry, others the skills and techniques specific to the use of scientific equipment, and still others the attitudes and values which permeate the scientific enterprise.

Assessment instruments are needed to assist teachers in evaluating student progress toward the various goals and objectives of physics courses in the Senior Division. For this reason, the Pool as it develops will consist of a variety of instrument types: objective instruments, including short answer, true-false, matching, and multiple choice; subjective instruments, including numerical problems, essay questions, and laboratory exercises; and other appropriate instrument types.

Specifying the Content Coverage

The initial effort has been directed to the assessment of the mastery of core topics in physics. To specify the content, each instrument has been coded to the appropriate Ministry of Education Curriculum guideline(s) - S-17A and S.17C. For example, an item on the refraction of light would be coded S-17A II.3.a and S.17C II.1.b. The Roman numeral designates the unit, and the number the topic within the unit. When the second phase of physics instruments is printed, a correspondence table will be included to assist teachers in coding the Phase I Instruments to the new Senior Division guidelines.

Where appropriate, each instrument has also been coded to the objectives contained in a document prepared by the Science Teachers' Association of Ontario Senior Division Physics: A Core Curriculum for Grades 11 and 13. The appropriate objectives for the Phase I Instruments have been included as an essential part of this package (Appendix A - STAO Content Objectives). For example, an instrument on the topic of refraction of light would

be coded 60 to indicate that it applies to the STAO objective 60 as listed under Behaviour of Light and Models of Light.

Specifying the Behaviour Coverage

In the assessment of achievement, both content and behaviour objectives should be considered. For the behaviour categories, the system developed by Leopold Klopfer* has been used. The complete Klopfer category system attempts to embrace all science education objectives. It includes such behaviour categories as knowledge, comprehension, the processes of scientific inquiry, application, manual skills, attitudes and interests, and orientation. An outline of the Klopfer Behaviour Categories is included in this package (Appendix B). For further details teachers should consult the reference cited.

Classifying Instruments Along Two Dimensions

The instruments in this collection are classified along two dimensions:

1. content (keyed to the Ministry of Education guideline(s) and the STAO Objectives);
2. behaviour (keyed to the Klopfer Categories).*

As an example, suppose that a teacher wishes to assess the students' grasp of Snell's Law of Refraction (S-17A II.3.a, S.17C II.1.b and STAO Objective 60). Several of Klopfer's behaviours relating to the Law may be tested: knowledge of the Law (Category A.8); recognition of the Law when stated in terms quite different from the formal textbook statement (Category A.10 or A.11); application of the Law in a straight-

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* Klopfer, L.E., Evaluation of Learning in Science. In Bloom, B.S., Hastings, J.T., and Madaus, G.F. Handbook of Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill, 1971.

forward numerical problem (F.1); or deducing the Law from a set of laboratory procedures (G.1). The latter may involve all or most of the behaviours listed under Category B (Processes of Scientific Inquiry: Observing and Measuring) and Category D (Processes of Scientific Inquiry: Interpreting Data and Formulating Generalizations) and in some cases could come after the processes described in Category C (Processes of Scientific Inquiry: Seeing a Problem and Seeking Ways to Solve It).

It is important that teachers realize that there was some degree of arbitrariness involved in classifying instruments by STAO Content Objectives and Klopfer Behaviour Categories. The behaviour objective(s) measured by an instrument depend(s) to a considerable extent on the way the particular subject matter was taught. An instrument may be similar to a task already done in class in which case it may be at the knowledge level, the application level, or even higher. It is felt, however, that the present assignment of objectives to instruments reflects the practice of most teachers in Ontario. It is recognized, however, that different approaches to physics teaching may warrant a change in categorization of an instrument by an individual teacher.

Layout of a Typical Instrument

The layout of a typical instrument is shown below. Notice that the codes are located in a column at the left. This permits the teacher to cover the code and photocopy instruments to be included in a test.

Topic Question No. — 14

Ministry Curriculum Guideline(s) — S17A I.2.e S17C III.3.b

STAO Content Objective(s) — 40

\+ Klopfer Behaviour Category(ies) — A8 F1

Correct Answer (Key) — (E)

++ Difficulty Level(s) — *** **

Grade 11 Advanced

Grade 13

A boy and a girl are sitting in the cafeteria eating lunch. They move so that the distance between them is now one-quarter as great as it was before. The force of attraction between them (gravitational, that is) is now about

(A) one-sixteenth as great

(B) one-quarter as great

(C) four times as great

(D) eight times as great

(E) sixteen times as great

Specifying the Difficulty Level

An estimated difficulty level for each instrument has been provided. This estimate is based on data derived from screening trials in a number of Ontario classrooms. One asterisk (*) identifies an instrument estimated to be easy (more than 75% of students at the appropriate grade levels are likely to choose/give a correct or acceptable response); two asterisks (**) identify an average or moderate instrument (one which between 50% and 75% of students are likely to answer acceptably); and three asterisks (***) identify an instrument classified as difficult (one which fewer than 50% of students are likely to answer acceptably).

It cannot be too strongly stressed that these ratings are estimates rather than rigid and infallible established standards. The estimated difficulty level is saying, in effect, that on the basis of how students have already

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\+ Where more than one category is given, the main one is given first.

++ See the following section for the meaning of the asterisks. Grade 11 General Difficulty Levels are not available for instruments in this first package. The second package will include more general level items.

performed on a particular instrument, the teacher of the "average" class, using the instrument with the grade for which it was screened, might reasonably expect this level of performance. But if the objective being tested by the instrument has not been the subject of recent instruction, if the student's first language is not English, if the student is especially gifted, or has particular difficulties, if the instrument has been screened by only a few students, or if any of these or a host of other factors come into play, teachers might not be too surprised by a performance that departs from the values provided. It is the responsibility of the teacher to judge each instrument as to its appropriateness for a particular group of students. Difficulty level is only one of many criteria to be used.

Arrangement of Instruments

The instruments are arranged in the same order as the topics in the STAO Senior Division Physics: A Core Curriculum for Grades 11 and 13 (Appendix A). The topic headings and subheadings, together with their symbols, are outlined in the Table of Contents and in Appendix A. The instruments are then arranged consecutively according to the STAO Content Objective number. Within each content category, instruments are arranged consecutively according to the Klopfer Behaviour Categories. As other kinds of instruments become available (short answer, essay, numerical problems, etc.), it is the intent to arrange them following the multiple choice instruments within each topic heading using the same system. It will facilitate for the teacher the selection of instruments which reflect specific instructional objectives.

Locating Instruments for a Specific Purpose

The classification of instruments along two dimensions makes it simple to locate instruments to meet specific needs. Use the following procedure:

1. Decide on the format of the instrument (multiple choice, short answer, essay question, numerical problem, etc.).
2. Scan the STAO Content Objectives (Appendix A) and select the range of content you wish to test.

   NOTE: Not all instruments can be assigned a specific STAO Objective number. The STAO document was not intended to cover all possible physics topics. Where an instrument is outside a STAO Content Objective, it is designated "S" (supplementary); where the instrument is close to a STAO Objective, but only approximately so, it is designated "S" followed by a STAO number. Thus S 9 describes an instrument whose objective is not quite 9, but is closer to it than to some other objective.
3. Scan the Klopfer Behaviour Categories (Appendix B) and select the behaviour you wish to test.

   NOTE: Some instruments can be assigned more than one Klopfer behaviour category. Where more than one category is given, the main one is given first.

Near-Duplicate Instruments

Some instruments are so similar to others that it is not prudent to have them appear in the same test. Near-duplicates have been included and are best used in the following situations:

1. Retesting of students after remedial help.
2. Testing the same objective in slightly different ways, where one may be preferred over the other by the teacher.
3. Testing the same objective on different occasions (e.g. end of sub-topic minitest and term test).

Conventions

The conventions adopted are the usual ones found in

secondary school physics. Approximate values of physical constants are used unless otherwise stated (e.g. 10 m/s^2 [down] for acceleration due to the earth's force of gravity; 3×10^8 m/s for the velocity of light in vacuo or in air). All graph axes are assumed to have uniform scales unless non-linear scales are indicated in a particular case. Students must be told which conventions apply when the instruments are used in class evaluation situations.

Suggested Uses for the Instruments

The instruments in this Pool may be used in the following or similar situations:

- final examinations
- term tests
- topic or subtopic tests
- weekly tests (five to ten instruments)
- spot tests
- reviews (as instructional tools)
- diagnostic tests (see notes below)
- feedback tests to judge the effectiveness of remedial work for students having difficulty with some aspect of physics

Diagnostic Tests

Physics is a hierarchical discipline. A grasp of basic terms and concepts is essential to an understanding of its laws and principles and ultimately its theories. As a result, students with a poor foundation or 'knowledge gap' experience more and more difficulty as the course progresses. The early identification of knowledge gaps is of great benefit to both student and teacher.

Diagnostic instruments are useful for identifying knowledge gaps. They measure achievement in a narrow content area.

Diagnostic instruments usually test only one concept or the mastery of a one-step task. Thus instruments can pinpoint specific strengths and weaknesses as a basis for remedial measures.

Diagnostic instruments can be used in two ways:

1. in a pre-test at the start of a topic or unit to determine students' command of the foundation terms and concepts essential for further work;
2. in a post-test given to those students who did poorly on an in-class test on the topic or unit.

In both bases, the teacher can initiate specific remedial procedures before the knowledge gap widens to the point where the student flounders.

Specific instruments in the OAIP Pool have not been identified as diagnostic ones, for what is a diagnostic instrument for one situation may not be for another. For example, an instrument could function as a diagnostic instrument for grade 13 students and as a regular end-of-course achievement instrument for grade 11 advanced students.

Constructing a Test

The following hints may be of assistance:

1. If more than one type of instrument is used in a test, be sure to group instruments of like format together, e.g. all multiple choice instruments first, all short answer instruments next, all essay questions/numerical problems last.

2. In order to save paper costs, some teachers may photo-reduce the assembled test before making copies. However, if a multiple choice instrument requires a student to

physically measure a quantity on the paper, photo-reduction of this instrument may result in the correct answer not being one of the choices available. Be on the lookout for situations of this nature.

Timing

Students should have adequate time to write the test. In planning a test, allow at least one and a half minutes per multiple choice instrument. It is much better for the students to have too much time than too little. When students rush through a test the later instruments usually give very distorted information on student achievement and spoil the reliability of the whole test.

Aids

Some instruments may require students to make physical measurements on the test paper. Advise students to bring a metric ruler and protractor when these are needed.

Security of Instruments

The Pool is open to the general public and to all educators in Ontario. It is preferred, however, that students not retain copies of the tests you administer. If students do not retain copies, you can use the instruments again, assured that each group of students approaches the tasks as did other groups. If you wish to make comparisons from class to class, or from year to year, you must feel sure that one group of students has not had the advantage of previewing the instruments that another group did not have.

If students retain copies, there is a danger that students may simply confine their studying to memorizing answers to instruments in circulation. This blind memorization is usually done to the exclusion of other more desirable learning activities,

and often defeats the attempts of the teacher who feels that rote memorization is not the purpose of education.

Sharing in Further Development of the Pool

The instruments in this document and those that remain to be published represent the efforts of knowledgeable and dedicated educators. However, there is a limit to what can be accomplished in a short span of time. For this reason, the collection of instruments published here should be viewed as only the first stage of an ongoing co-operative effort to develop a comprehensive Pool of assessment materials for secondary school physics. Teachers using these materials can help in that development by:

1. identifying errors and ambiguities which may exist in the instruments;
2. identifying and providing examples of ways in which instruments can be modified or adapted to address different objectives or to meet the needs of students in courses with differing levels of ability;
3. identifying gaps in coverage of topics or instrument types;
4. suggesting modifications either to the instruments or to the organization of the materials so that they could be more easily used in the assessment process.

Comments, suggestions and examples should be forwarded to:

OAIP Physics Project
Research Branch
Ministry of Education
Mowat Block, Queen's Park
Toronto, Ontario
M7A 1L2

Acknowledgements

The Ministry of Education wishes to acknowledge the contributions of the following people who assisted in developing the Senior Division Physics Section of the Ontario Assessment Instrument Pool.

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APPENDIX A

STAO CONTENT OBJECTIVES*

CORE TOPICS

Objective No.		
		MEASUREMENT - M
1		1. Express any number in scientific notation (standard form).
2		2. Express experimental measurements with the appropriate number of significant digits (e.g. 2.0 cm instead of 2 cm).
3		3. Express calculations from experimental data to the appropriate number of significant digits (e.g. 3.5 cm x 8.27 cm = 29 cm^2).
4		4. Express all measurements in the appropriate SI units (as outlined in the current edition of the Metric Guide, formerly the Metric Style Guide).
5		5. Realize that the results of experiments in physics are not exact and determine the percent deviation in the final result of a calculation, given the accepted value.
	E+	6. Realize that the results of experiments in physics are not exact, and, for example, be able to:
6		(a) define the terms absolute error, relative error, percentage error;
7		(b) determine the absolute and the relative errors for measurements made in an experiment;
8		(c) determine the absolute and relative error in the final answer when measured quantities are used to calculate the answer.

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* The Science Teachers' Association of Ontario, Senior Division Physics: A Core Curriculum for Grades 11 and 13, STAO Science Resource Centre, Queen's University, Kingston, Ontario, 1977.

\+ Note: the symbol E is used throughout the core topics section to designate those objectives whose achievement through laboratory experiments is highly recommended.

Objective
No.

FUNCTIONS - F

E 1. Carry out the following operations, given a table containing experimental data.+

9 (a) Plot the data on a graph;

10 (b) Recognize from the graph whether it is reasonable to assume a linear relationship;

11 (c) If the relationship is linear, write the proportionality statement and the equation;

12 (d) Replot the data to yield a straight line if the relationship is non-linear, and write the proportionality statement and equation of the line;

13 (e) Given a graph, interpolate and extrapolate.

KINEMATICS - K

Motion in a Straight Line - K-MSL

14 E 1. Collect sufficient data from a record of motion (ticker tape, photograph, etc.) and represent the motion graphically (position-time graph or velocity-time graph).

15 2. Given a position-time graph illustrating constant velocity motion, deduce the velocity.

16 3. Given a position-time graph of any motion, deduce the velocity of any instant.

4. Given a velocity-time graph illustrating constant acceleration, deduce:

17 (a) the acceleration of the object;

18 (b) the position of the object at any instant;

19 (c) an analytical relation for acceleration, that is,

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

20 (d) an analytical relation for displacement, that is

$$\Delta\vec{d} = \frac{(\vec{v}_f + \vec{v}_i)\Delta t}{2}$$

and identify situations in which this equation is applicable.

+ Data are limited to linear, power law, inverse relationship, and inverse square relationships.

Objective No.		
21		5. Solve problems using the equations in 4 (c) and 4 (d) above and in so doing become familiar with the fact that the preferred units of velocity and acceleration in SI are derived from the metre and second.

Motion in a Plane and Vectors - K-MPV

22		6. (a) Express any position in a plane by the use of a fixed reference point and a vector.
23		(b) Deduce the vector which represents the displacement between any two positions.
24	E	(c) Construct a vector equal to the sum of two or more given vectors.
25		(d) Construct a vector equal to the difference between two given vectors.
26		(e) Construct a vector equal to the product of a scalar quantity, or a number, times a vector.
27		(f) Given two positions in a plane and the time to move from one to the other, calculate the average velocity vector $\vec{v}_{av} = \frac{\Delta \vec{d}}{\Delta t}$
28		(g) Given any vector in a plane, use trigonometry or a scale diagram to determine two mutually perpendicular components of the vector.
29		(h) Determine the change in velocity vector and the acceleration vector for the motion of a projectile.
30		(i) Calculate the average vector acceleration for an object moving in a circle at constant speed, expressing the answer in some examples in metres per second squared (m/s^2). $\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$

DYNAMICS - D

Force and Newton's Laws - D-FNL

31		1. (a) Describe what is meant by the term "force". Identify the vector nature of force and determine the resultant of a system of two or more forces expressed in newtons (see also item 35).

Objective No.		
32	E	(b) Recognize that if no unbalanced (net) force acts on an object, that object will continue in its present state of rest or uniform motion.
33	E	(c) Recognize that when an unbalanced (net) force does act on an object, the object is accelerated in the direction of the force.
34	E	(d) Do an experiment to illustrate the direct relation between the unbalanced (net) force applied to an object and the acceleration it experiences.
35		(e) Define the newton as the unit of force. Given any two of acceleration, mass, or unbalanced (net) force, deduce the third of these variables using the relationship $\vec{a} = \frac{\vec{F}}{m}$
36		(f) State what is meant by the terms inertial mass and gravitational mass.
37		(g) Given a description of a force, state the reaction force.

Centripetal Force and Gravitation - D-CFG

38	E	(h) Use $F = \frac{mv^2}{R}$ and $\vec{F} = -\frac{4\pi^2 m\vec{R}}{T^2}$ to solve circular motion problems.
39		(i) State Kepler's laws of motion.
40		(j) State Newton's Universal Law of Gravitation and use $F = \frac{Gm_1m_2}{R^2}$ to solve problems illustrating the inverse square law $G = 6.670 \times 10^{-11}\ \mathrm{N\cdot m^2\cdot kg^{-2}}$

Impulse and Conservation of Momentum - D-ICM

41	E	2. (a) Define momentum and state the primary SI units of momentum.
42		(b) Solve problems using $\vec{p} = m\vec{v}$ and $\vec{F}\Delta t = m\Delta\vec{v} = \Delta\vec{p}$.
		(c) Apply the principle of conservation of momentum involving the interaction of two or more masses in a:
43		(i) one-dimensional collision or explosion
44		(ii) two-dimensional collision or explosion.

Objective No.		

Work and Kinetic Energy - D-WKE

45 E 3. (a) (i) Deduce work as a measure of energy transfer.

46 (ii) Define the joule as the unit of energy and work.

47 (b) Calculate the work done on an object as being equal to the magnitude of the component of the force in the direction of the motion times the displacement.

48 (c) (i) Define power and the SI unit of power, the watt.

49 (ii) Solve problems involving power using the watt as the unit of power, and the watt second as an equivalent form of the joule.

50 (d) Recognize a situation in which the component of a force is perpendicular to the displacement and recognize that no work is done by that component of force.

51 (e) Define kinetic energy as energy due to the motion of the mass of an object.

52 (f) State the relation between work and kinetic energy (that is, when work results only in the acceleration of an object, then the work done is equal to the kinetic energy gained by the object, neglecting friction).

53 (g) State the relation between kinetic energy, mass, and velocity (that is $E_K = \frac{1}{2}mv^2$) and given all but one of those variables, calculate the unknown.

54 (h) Use the principles of conservation of momentum and kinetic energy in a one-dimensional elastic collision to determine the velocities of the two masses after the collision, given their masses and velocities before the collision.

Gravitational Potential Energy - D-GPE

55 4. (a) State the relationship between the change in gravitational potential energy near the surface of the earth and the height of a mass m above the surface ($\Delta U = mg\Delta h$) and solve problems.

56 E (b) Describe the energy conversion occurring in an object falling toward the earth, neglecting friction.

57 (c) Recognize the mutual nature of potential energy (i.e. a property of the system) and discuss gravitational potential energy using the relationship

$$U_G = -\frac{Gm_1m_2}{R}$$

Objective No.

BEHAVIOUR OF LIGHT AND MODELS OF LIGHT - L

Geometric Optics - L-GO

58 1. List the properties of light such as:

(a) transmission through a vacuum;

E (b) linear propagation;

(c) speed of light.

59 E 2. Determine the path taken by a ray of light given the direction of the incident ray and the orientation of the reflecting surface (plane or curved) with respect to the incident ray.

60 E 3. Determine the path taken by a ray of light given the direction of the incident ray, the orientation of the refracting interface, and the index of refraction of the refractive medium.

61 E 4. Recognize that light may be simultaneously reflected and refracted at an interface.

Particle Model of Light - L-PML

62 5. (a) Explain what is meant by the term scientific model.

63 E (b) Describe the particle model of light.

6. Describe the predictions made by the particle model about the following properties of light:

64 (a) reflection;

65 E (b) refraction (Snell's Law: $n = \frac{\sin i}{\sin r}$);

66 (c) propagation through a vacuum;

67 (d) the inverse square law of intensity.

68 7. Explain the difficulties encountered by the particle model such as speed of light in a vacuum and partial reflection and transmission.

Characteristics and Behaviours of Waves - L-CBW

69 E 8. Define or describe the following terms related to the transmission of energy by waves: vibration, frequency, hertz, period, amplitude, wave, periodic wave, transverse wave, longitudinal wave, wavelength, crest, trough, vibrating in phase, universal wave equation.

Objective No.		
70	E	9. Solve problems using the universal wave equation ($v = f\lambda$), noting that $f = 1/T$ where frequency is in hertz and the period is in seconds, and that $m \cdot Hz = m.s^{-1} = m/s$.
	E	10. Draw a diagram to illustrate how a plane wave in water:
71		(a) reflects from a straight barrier;
72		(b) refracts from deep to shallow water and vice versa;
73		(c) simultaneously reflects and refracts.
74	E	11. Show, by means of sketches, how slit width and wavelength affect the amount of diffraction of water waves, as in a ripple tank, for example.
		<u>Interference of Periodic Waves</u> - L-IPW
75	E	12. (a) Construct the resultant pulse given an accurate description or drawing of the two interfering pulses.
76		(b) State the conditions under which standing waves will be produced.
77		(c) Determine the wavelength given a standing wave pattern.
78		(d) Identify areas of constructive and destructive interference in a two-dimensional medium in which two sources are vibrating in phase.
79		(e) Verify the relationship [path length difference = $(n - \frac{1}{2})\lambda$] for destructive interference given the diagram of an interference pattern produced by two point sources.
80		(f) Describe how the pattern in (d) will change if the two sources are made to vibrate with a changing phase.
		<u>Wave Model of Light and Interference</u> - L-WML
	E	13. Explain the prediction made by the wave model about the following properties of light:
81		(a) reflection;
82		(b) refraction (Snell's Law: $\frac{\sin i}{\sin r} = n = \frac{\lambda_i}{\lambda_r} = \frac{v_i}{v_r}$)

Objective No.		
83		(c) simultaneous reflection and refraction.
84	E	14. (a) Describe the experimental conditions that must be fulfilled in order to observe interference of light predicted by the wave model.
85		(b) Derive the equation $\lambda = \frac{d\Delta x}{L}$ from $\frac{x_n}{L} = \frac{(n - \frac{1}{2})\lambda}{d}$ and use it to solve problems.
86		(c) Determine the wavelength, generally expressed in nanometres (nm), of light by experiment, given a monochromatic light source and a double-slit separation.
87		(d) Describe the pattern produced by a single slit.
88		15. Explain the difficulties encountered by the wave model, such as transmission through a vacuum.
		<u>ELECTRICITY AND MAGNETISM</u> - EM
		<u>Electric Forces and Charges</u> - EM-EFC
89		1. Recognize that like charges repel and unlike charges attract.
90	E	2. (a) State Coulomb's Law: $F \propto \frac{q_1 q_2}{R^2}$ and hence that the force in newtons is given by the equation: $F = \frac{Kq_1 q_2}{R^2}$ where the charges are in coulombs, the distance between them in metres, and $K = 8.988 \times 10^9\ N{\cdot}m^2{\cdot}C^{-2}$
91		(b) Solve problems using the law.
92		(c) Vectorially add electric forces that are coplanar.
		<u>Electric Field and Potential</u> - EM-EFP
93	E	3. (a) Define electric force field.
		(b) Describe (with the aid of a diagram) the electric force field:
94		(i) about a single charged metal sphere;
95		(ii) between two oppositely charged parallel metal plates.

Objective No.		
96		4. Write the equation which describes the potential energy stored in a system consisting of two point charges as a function of q_1, q_2, and R, and solve problems using this equation.
97		5. Compare $U_E = \frac{Kq_1 q_2}{R}$ and $U_G = \frac{G m_1 m_2}{R}$
98	E	6. Explain the significance of Millikan's experiment.
99	E	7. Describe the motion of electrons in a uniform electric force field.
		<u>Current Electricity and Electromagnetism</u> - EM-CEE
100	E	8. Cite evidence for the fact that electricity can be generated through the transfer of energy from other sources.
101		9. Define current and potential difference and realize that current is stated in amperes (A) and potential difference in volts (V).
102	E	10. State the relationship between the potential difference across the ends of an ohmic conductor and the current through it (Ohm's Law).
103		11. Define the ohm (Ω) as the unit of resistance.
104	E	12. Solve problems involving Ohm's Law, $V = I R$, including examples with resistors in series and examples with resistors in parallel, which illustrate the conservation of energy and charge in simple circuits.
105	E	13. Define the power rating of electrical appliances.
106	E	14. Solve problems involving the cost of electrical energy and apply some of these problems to the wise use of energy.
107	E	15. Describe the magnetic force between two straight parallel conducting wires in which moving electrons constitute a current.
108	E	16. Describe the magnetic force field (magnitude and direction) about conductors in which moving electrons constitute a current (i) in a straight wire (ii) in a single loop (iii) in a helix or coil

Objective No.		
109	E	17. Describe the motion of electrons in a uniform magnetic force field for electrons moving perpendicular to the field.
		<u>Electromagnetic Spectrum</u> - EM-ES
110		18. (a) List the types of radiations that make up the electromagnetic radiation spectrum.
111		(b) Describe the conditions under which an electromagnetic wave is generated and list characteristics common to all electromagnetic waves.
112	E	(c) Recognize emission line spectra and describe how they may be produced.
113		(d) Realize that the line spectrum produced by an atom is a characteristic property of that atom.
		<u>WAVE/PARTICLE DUALITY OF ELECTROMAGNETIC RADIATION AND MATTER</u> - WPD
		<u>Photons</u> - WPD-P
114	E	1. Explain how the photoelectric effect supports the particle theory of light.
115		2. Explain the significance of the interference effects associated with light of extremely low intensity (Taylor's experiment).
116		3. Give an account of Einstein's interpretations of the photoelectric effect ($E_k = hf - B$), where Planck's constant $h = 6.626 \times 10^{-34}$ J·s $= 4.136 \times 10^{-15}$ eV·s.
117		4. Define electron-volt (eV).
118		5. Solve problems involving the relationship $E_k = hf - B$
119		6. Explain the significance of the Compton effect.
120		7. Calculate the momentum of a photon given its frequency or wavelength, $p = \frac{h}{\lambda} = \frac{hf}{c}$.
121		8. Explain under what conditions of the interaction of electromagnetic radiation with matter (i.e. exchange of energy or momentum or both) the particle nature of electromagnetic radiation is predominant and under what conditions the wave nature is predominant.

Objective No.

Matter Waves - WPD-MW

122 E 9. Describe the conditions under which matter exhibits a wave nature.

123 10. Calculate the deBroglie wavelength of a particle given its mass and velocity

$$(\lambda = \frac{h}{mv})$$

124 11. Explain under what conditions of the interaction of elementary particles (electrons, neutrons) with matter (i.e. interaction being the exchange of energy or momentum or both) the particle nature of matter is predominant and under what conditions the wave nature is predominant.

THE ATOM - A

The Rutherford Model - A-RM

125 1. (a) Describe qualitatively Rutherford's experiment.

126 (b) Describe the model of the atom inferred from Rutherford's experiment.

127 (c) Discuss predictions made by Rutherford's classical atomic model that are inconsistent with the observed behaviour of atoms.

Energy Levels - A-EL

128 2. (a) Cite evidence that the energy of atoms increases in discrete steps (Franck-Hertz).

129 (b) Cite evidence that a characteristic set of energy levels exists for each atom.

(c) Given an energy level diagram for a specific element:

130 (i) State the ionization energy of the element.

131 (ii) Determine the energy of photons that could be produced when the atom is excited.

132 (iii) Determine the energies of photons the atom will absorb.

Objective No.

133 E 3. Verify the equation $E = \frac{13.6}{n^2}$ eV by experimental observation of the spectrum of atomic hydrogen after observing the teacher derive the equation theoretically.

NUCLEAR ENERGY - NE

134 1. (a) Compare the size and density of the nucleus as discovered in the Rutherford experiment with the size and density of the atom.

135 (b) Define atomic number, mass number, and isotope.

136 2. (a) Compare the mass and charge of nucleons with the mass and charge of electrons.

137 (b) Compare qualitatively the range and strength of the nuclear force with the range and strength of the electric force.

138 3. (a) Write the equation for each of alpha, beta, and gamma decay of a nucleus.

139 (b) Compare the mass, charge, energy, and ability to penetrate matter for the products of alpha, beta, and gamma decays.

140 4. Write the equations for a neutron-gamma nuclear reaction and be able to account for the change in the masses and energies of the constituents of the reaction using the equation $E = mc^2$.

141 5. (a) Distinguish between the nuclear fission and nuclear fusion reactions and the environments necessary for their completion.

142 (b) Write the equations for the fusion reactions in the sun and the fission reaction in the CANDU reactor.

APPENDIX B

KLOPFER BEHAVIOUR CATEGORIES*

A. KNOWLEDGE AND COMPREHENSION

A.1 Knowledge of specific facts

A.2 Knowledge of scientific terminology

A.3 Knowledge of concepts of science

A.4 Knowledge of conventions

A.5 Knowledge of trends and sequences

A.6 Knowledge of classifications, categories and criteria

A.7 Knowledge of scientific techniques and procedures

A.8 Knowledge of scientific principles and laws

A.9 Knowledge of theories or major conceptual schemes

A.10 Identification of a fact, concept, procedure, classification scheme, or theory in a new context

A.11 Translation of a fact, term, concept, trend, principle, or theory presented in one symbolic form to another symbolic form

B. PROCESSES OF SCIENTIFIC INQUIRY I: OBSERVING AND MEASURING

B.1 Observation of objects and phenomena

B.2 Description of observations using appropriate language

B.3 Measurement of objects and changes

B.4 Selection of appropriate measuring instruments

B.5 Estimation of measurements and recognition of limits in accuracy of measurements

C. PROCESSES OF SCIENTIFIC INQUIRY II: SEEING A PROBLEM AND SEEKING WAYS TO SOLVE IT

C.1 Recognition of a problem

C.2 Formulation of a working hypothesis

C.3 Selection of suitable tests of a hypothesis

C.4 Design of appropriate procedures for performing experimental tests

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* Klopfer, L.E., Evaluation of Learning in Science. In Bloom, B.S., Hastings, J.T., and Madaus, G.F. Handbook of Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill, 1971.

D. PROCESSES OF SCIENTIFIC INQUIRY III: INTERPRETING DATA AND FORMULATING GENERALIZATIONS

D.1 Processing of experimental data

D.2 Presentation of data in the form of functional relationships

D.3 Interpretation of experimental data and observations

D.4 Extrapolation, when warranted, of functional relationships beyond actual observations, and interpolation between observed points

D.5 Evaluation of hypothesis under test in the light of the experimental data obtained

D.6 Formulation of appropriate generalizations (empirical laws or principles) that are warranted by the relationships found

E. PROCESSES OF SCIENTIFIC INQUIRY IV: BUILDING, TESTING, AND REVISING A THEORETICAL MODEL

E.1 Recognition of need for a theoretical model to relate different phenomena and empirical laws or principles

E.2 Formulation of a theoretical model to accommodate the known phenomena and principles

E.3 Specification of phenomena and principles that are satisfied or explained by a theoretical model

E.4 Deducation of new hypotheses from a theoretical model to direct observations and experiments for testing it

E.5 Interpretation and evaluation of the results of experiments to test a theoretical model

E.6 Formulation, when warranted by new observations or interpretations, of a revised, refined, or extended theoretical model

F. APPLICATION OF SCIENTIFIC KNOWLEDGE AND METHODS

F.1 To new problems in the same field of science

F.2 To new problems in a different field of science

F.3 To problems outside of science (including technology)

G. MANUAL SKILLS

G.1 Development of skills in using common laboratory equipment

G.2 Performance of common laboratory techniques with care and safety

H. ATTITUDES AND INTERESTS

H.1 Manifestation of favorable attitudes toward science and scientists

H.2 Acceptance of scientific inquiry as a way of thought

H.3 Adoption of habits of thought which ideally characterize scientists when engaged in inquiry ("scientific attitudes")

H.4 Enjoyment of science learning experiences

H.5 Development of interests in science and science-related activities

H.6 Development of interest (for some students) in pursuing a career in science or in science-related work

I. ORIENTATION

I.1 Distinction between various types of statements in science (e.g. observation, interpretation, law, theory) and their relationship to one another

I.2 Recognition of the limitations of scientific explanation and of the influence of scientific inquiry on general philosophy

I.3 Historical Perspective: Recognition that the past, present, and future development of science is a product of its own history and a reflection of the general culture of its time

I.4 Realization of the relationships existing among scientific progress, technical achievements, and economic development

I.5 Awareness of the social and moral implications of scientific inquiry and its results for the individual, community, nation, and the world

MEASUREMENT

1 10^{-3} divided by 10^{-11} equals

S17A
I.1.a
S17C
I.1.d

1

A2

(A)

**
-

(A) 10^{8}

(B) 10^{-8}

(C) 10^{14}

(D) 10^{-14}

(E) $10^{3/11}$

2 The number of metres in 12 km is

S17A
I.1.c
S17C
I.1.a

1

A4

(A)

***

(A) 1.2×10^{4}

(B) 1.2×10^{3}

(C) 1.2×10^{1}

(D) 1.2×10^{-2}

(E) 1.2×10^{-3}

3 The number of amperes in 85 mA is

S17A
III.2.c
S17C
IV.2.b

1

A4

(D)

**
-

(A) 8.5×10^{4}

(B) 8.5×10^{3}

(C) 8.5×10^{1}

(D) 8.5×10^{-2}

(E) 8.5×10^{-5}

4

S17A
I.3.d

1

A4

(A)

***

A turbo-generator has a power output of 300 MW. This output is equal to

(A) 3.00×10^{8} W

(B) 3.00×10^{6} W

(C) 3.00×10^{5} W

(D) 3.00×10^{2} W

(E) 3.00×10^{-1} W

5

S17A
I.1.d
S17C
I.1.d

1, 2

A4

(E)

**

The number 25 700 expressed in scientific notation (standard form) correct to two significant digits would be written

(A) 2.5×10^{4}

(B) 0.25×10^{5}

(C) 0.26×10^{5}

(D) 2.6×10^{5}

(E) 2.6×10^{4}

6

S17A
I.1.b
S17C
I.1.a

1

F2

(B)

-

***

The geological past is often divided into eras and periods according to the chart below.

Era	Period	Years elapsed to present
		present
Cenozoic	Quaternary	1.7×10^6
	Tertiary	5.5×10^7
Mesozoic	Cretaceous	1.2×10^8
	Jurassic	1.3×10^8
	Triassic	1.5×10^8
Paleozoic	Carboniferous	2.7×10^8
	Devonian	3.0×10^8
	Silurian	3.5×10^8
	Ordovician	3.8×10^8
	Cambrian	4.7×10^8
Proterozoic	Pre-Cambrian	1.0×10^9

Since the close of the Proterozoic era, the longest period listed is the

(A) Cambrian

(B) Carboniferous

(C) Cretaceous

(D) Tertiary

(E) Quaternary

7

S17A
I.1.b
S17C
I.1.a

1

F2

(E)

\-

**

The geological past is often divided into eras and periods according to the chart below.

Era	Period	Years elapsed to present
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Cenozoic	Quaternary	1.7×10^6
	Tertiary	5.5×10^7
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	Jurassic	1.3×10^8
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Paleozoic	Carboniferous	2.7×10^8
	Devonian	3.0×10^8
	Silurian	3.5×10^8
	Ordovician	3.8×10^8
	Cambrian	4.7×10^8
Proterozoic	Pre-Cambrian	1.0×10^9

The ratio of the length of the Cambrian period to the Ordovician period is approximately

(A) 3×10^8

(B) $\frac{1}{3} \times 10^8$

(C) $\frac{1}{3}$

(D) 1

(E) 3

8

S17A
I.1.d

2

A4

(D)

***
-

A brass replica of the standard metre is found to have a length of one metre, zero centimetres and zero millimetres. Further accuracy to the fraction of a millimetre is not known. This measurement is correctly expressed as

(A) 1 m

(B) 1.0 m

(C) 1.00 m

(D) 1.000 m

(E) 1.0000 m

9

S17A
I.1.d

2

A4

(D)

**
***

How many significant digits are there in the number 0.340 050?

(A) 3

(B) 4

(C) 5

(D) 6

(E) 7

10

S17A
I.1.d

2

A4

(C)

***
*

How many significant digits are there in the number 0.020 59?

(A) 2

(B) 3

(C) 4

(D) 5

(E) 6

11

S17A
I.2.a
S17C
I.3

3

A4

(B)

**
**

A student runs at a constant speed of 3.5 m/s for 105 s. The total distance travelled, expressed to the correct number of significant digits, is

(A) 0.36 km

(B) 0.37 km

(C) 0.367 km

(D) 0.368 km

(E) 0.3675 km

12

S17A
I.1
S17C
I.1.d

4

A2

(B)

***
***

A particle accelerator has a beam current of 90 nA (nanoamperes). (Nano = 10^{-9}) Expressed to the nearest order of magnitude, this current, in amperes, is

(A) 10^{2}

(B) 10^{-7}

(C) 10^{-9}

(D) 10^{-10}

(E) 10^{-12}

13

S17A
I.1.a

4

A4

(E)

*
\-

Which one of the following expressions employs correct SI usage?

(A) eight Joules

(B) eight J

(C) 8 joules

(D) 8 Joules

(E) 8 J

14

S17A
I.1.a

4

A4

(A)

*

-

In an experiment to measure the force of gravity, the students expressed the result in three different ways:

I. 28 N

II. 28 newtons

III. 28 Newtons

Which of these expressions conform(s) to correct SI usage?

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) II and III only

15

S17A
I.1.b
S17C
I.1.d

S

A1
F1

(D)

-

***

A man who is thirty years of age has lived about

(A) 10^{6} s

(B) 10^{7} s

(C) 10^{8} s

(D) 10^{9} s

(E) 10^{10} s

16

S17A
I.1

S

B5

(C)

-

***

The best estimate of the total volume of eight rooms of a typical modern house is

(A) 30 m^3

(B) 60 m^3

(C) 300 m^3

(D) 3000 m^3

(E) 6000 m^3

17

S17C
I.1.b

S

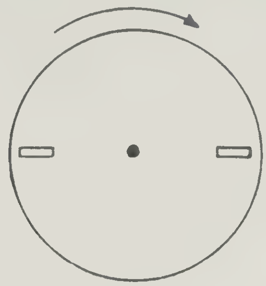
F1
B3
A7

(C)

-

***

A stroboscope consists of a disc containing 2 slots as shown below. The disc rotates at a constant speed, making 30 revolutions in 10 s. When a rotating fan with 4 equally spaced identical blades is viewed through the stroboscope, it appears to be "stopped."



The fan

(A) cannot have a frequency greater than 6 Hz

(B) must have a frequency of at least 6 Hz

(C) must have a frequency of at least 1.5 Hz

(D) can have its frequency determined exactly from the information given

(E) must rotate in the same direction as that of the stroboscope

18

S17C
I.1.b

S

F1
A8

(C)

-

***

An experimenter punches ten holes in a cardboard disc, spacing them evenly around the rim. He holds the disc, spinning at a frequency of 6 Hz, in front of one eye and looks through the holes at a vibrating violin string. The string is tightened until its frequency is 306 Hz. The string now appears to be vibrating slowly with a frequency of

(A) 1 Hz

(B) 5 Hz

(C) 6 Hz

(D) 41 Hz

(E) 51 Hz

19

S17C
I.1.b

S

F1
A8

(A)

-

***

A movie film (exposed at 24 pictures per second) is made of a rotating disc with a white spot at the edge. Two stationary images of the spot appear when the film is projected.

Consider the following frequencies of the rotating disc (expressed in Hz).

I. 6 II. 12 III. 48 IV. 96

Which of the above choices is/are possible frequencies for the rotating disc?

(A) II only

(B) III only

(C) I and II only

(D) II and III only

(E) III and IV only

FUNCTIONS

1

S17C
I.2.b

S 9

A11
A7
F1

(E)

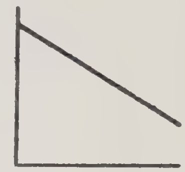
\-

***

If $x_1y_1 = x_2y_2 = \ldots = x_{10}y_{10}$, where (x_1, y_1), $(x_2, y_2) \ldots (x_{10}, y_{10})$ are sets of measurements from a given experiment, which one of the following graphs would best represent a plot of y along the vertical axis and x along the horizontal axis?

(A) 

(B) 

(C) 

(D) 

(E) 

2

S17C
I.2.b

S 9

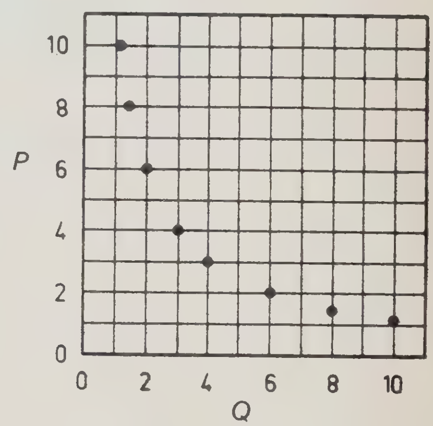
D2
A11

(C)

\-

***

The measured values of P and Q as obtained in an experiment were plotted as shown in the figure.



Which one of the following relationships best fits the experimental results?

(A) $P \propto Q$

(B) $P \propto Q^2$

(C) $P \propto \frac{1}{Q}$

(D) $P \propto \frac{1}{Q^2}$

(E) $Q \propto \frac{1}{P^2}$

3

S17C
I.2.b

10

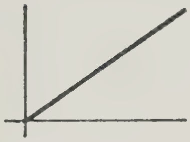
A11

(E)

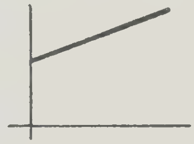
\-

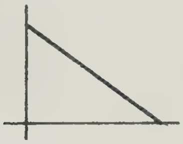
***

Two interdependent physical quantities P and Q are found to vary in such a way that their product is a constant. When P is plotted against Q, the shape of the curve generated is most like

(A) 

(B) 

(C) 

(D) 

(E) 

4

S17C
I.2.b

10

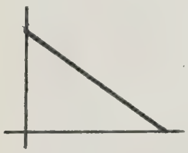
A11

(D)

\-

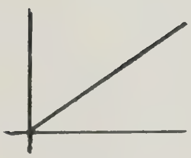
***

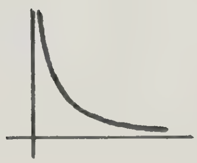
Two interdependent physical quantities, R and S are found to vary in such a way that their product is a constant. If the reciprocal of R were plotted against S, the shape of the curve generated is most like

(A) 

(B) 

(C) 

(D) 

(E) 

5

S17C
I.2.b

S 10

D6
D3

(B)

-

***

The table below shows a set of approximate measurements made for the drag d on a racing car, corresponding to various speeds v.

Drag (d) in kilonewtons	Speed (v) in kilometres per hour
0.25	10
1.00	20
4.00	40
6.25	50
12.25	70
25.00	100

From these data it may be stated that the drag d is proportional to

(A) v^3

(B) v^2

(C) $1/v^2$

(D) $1/v$

(E) $\sqrt{v}$

6

S17A
I.2.a
S17C
I.2.b

11

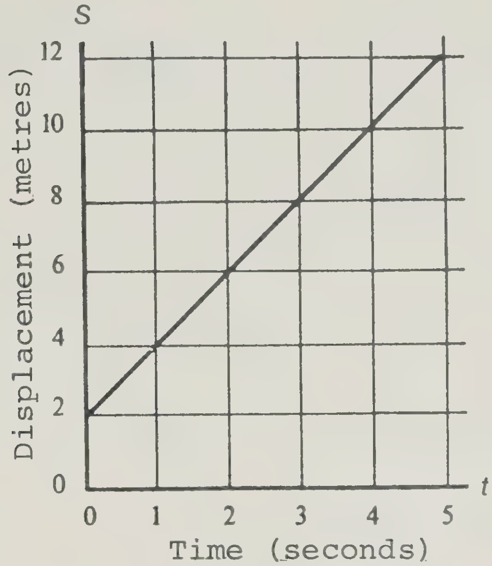
A11
A7

(C)

\-

**

If S is the displacement and t is the time, the equation of the line shown in the graph below is



(A) $S = 2t$

(B) $S = 2 + t$

(C) $S = 2(1 + t)$

(D) $2S = 4 + t$

(E) $S = 2 + \frac{12}{5}t$

7

S17C
I.2.b

12

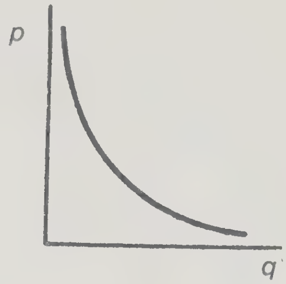
A7
A11

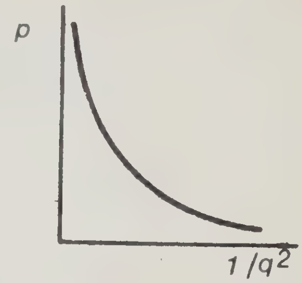
(E)

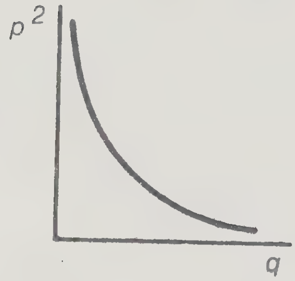
–

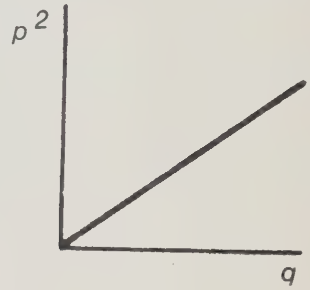
***

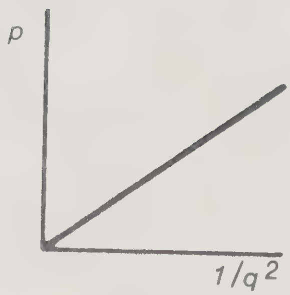
The equation $p = \frac{k}{q^2}$ with k a constant is best represented by which one of the following graphs?

(A)


(B)


(C)


(D)


(E)


8

S17C
I.2.b

S12

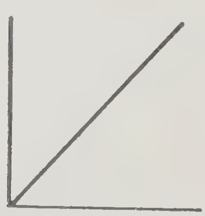
A7
A11

(D)

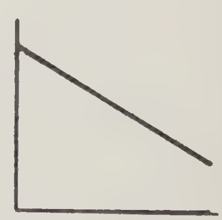
–

***

If $y \propto \frac{1}{x^2}$, which of the following graphs would best represent a plot of y along the vertical axis and $\frac{1}{x}$ along the horizontal axis?

(A)


(B)


(C)


(D)


(E)


9

S17A
I.2.e
S17C
I.2.b

12

A7
F1

(B)

-

**

The mathematical relationship between gravitational force F and distance d can be written as

$$F \propto 1/d^2 \quad \text{or} \quad F = k/d^2$$

Which of the following graphing procedures would indicate this relationship by yielding a straight-line graph?

(A) plotting F against d^2

(B) plotting F against $1/d^2$

(C) plotting F against d

(D) plotting F against $1/d$

(E) plotting d against F

10

S17C
I.2.b

12

A7
F1

(E)

-

***

The speed of ripples on a water surface is given by the relation, $v = \sqrt{\frac{2\pi S}{\lambda d}}$, where v is the speed, S and d are constants, and λ is the wavelength of the ripples. For this relation, which one of the following plots will give a straight line graph?

(A) v plotted against λ^2

(B) v^2 plotted against λ

(C) v plotted against $\frac{1}{\lambda}$

(D) v plotted against $\frac{1}{\lambda^2}$

(E) v^2 plotted against $\frac{1}{\lambda}$

11

S17C
I.2.b

12

D3

(A)

***
***

A set of experimentally gathered data is presented in the following table:

N	S
0	0
2	2
4	8
6	18
8	32

Which of the following proportionality statements correctly expresses the relationship between N and S ?

(A) $S \propto N^2$

(B) $S \propto N$

(C) $S \propto \sqrt{N}$

(D) $S \propto \frac{1}{\sqrt{N}}$

(E) $S \propto \frac{1}{N^2}$

12

S17C
I.2.b

S12

F1
A8

(D)

\-

***

If the diameter of the sun is 10^9 m and that of the earth is 10^7 m, how many times greater is the volume of the sun than the volume of the earth?

(A) 10^2

(B) 10^3

(C) 10^4

(D) 10^6

(E) 10^8

13 The following table records measurements made on two spheres:

S17C
I.2.b

S 12

F1
D3

(E)

-
**

	Sphere F	Sphere G
density (kg/m^3)	2×10^3	3×10^3
radius (m)	6×10^{-2}	4×10^{-2}

The mass of a sphere varies directly with the product of its density and the cube of its radius. The ratio of the mass of Sphere F to that of Sphere G is

(A) 4 to 9

(B) 2 to 3

(C) 1 to 1

(D) 3 to 2

(E) 9 to 4

14 A quantity s is measured as a function of a variable t. The results are tabulated below.

S17C
I.2.c

S 13

D4

(B)

-
***

s	t
2	1
8	2
18	3
32	4

The most likely value of s for $t = 2.5$ is

(A) 11

(B) 12.5

(C) 13

(D) 13.5

(E) 14.5

K I N E M A T I C S

MOTION IN A STRAIGHT LINE

1 If air resistance is neglected, which graph best represents a speed-time graph for an object dropped from a building?

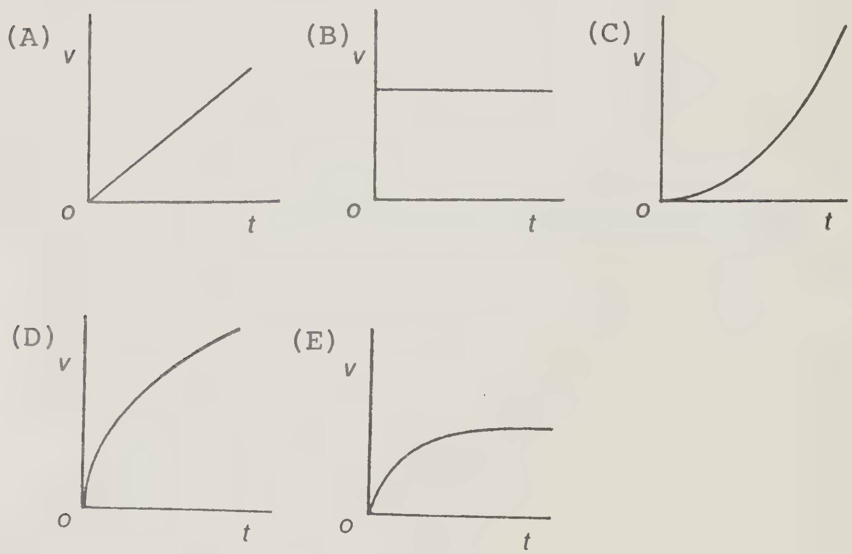
S17A
I.2.a
S17C
I.3.b

14

A11

(A)

***
***



2

S17A
I.2.a
S17C
I.4.d

14, 26

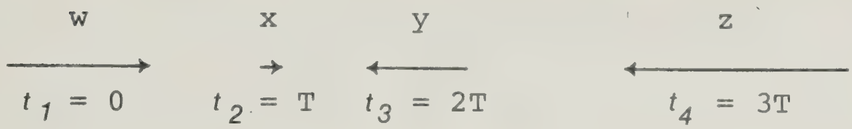
A11
F1

(A)

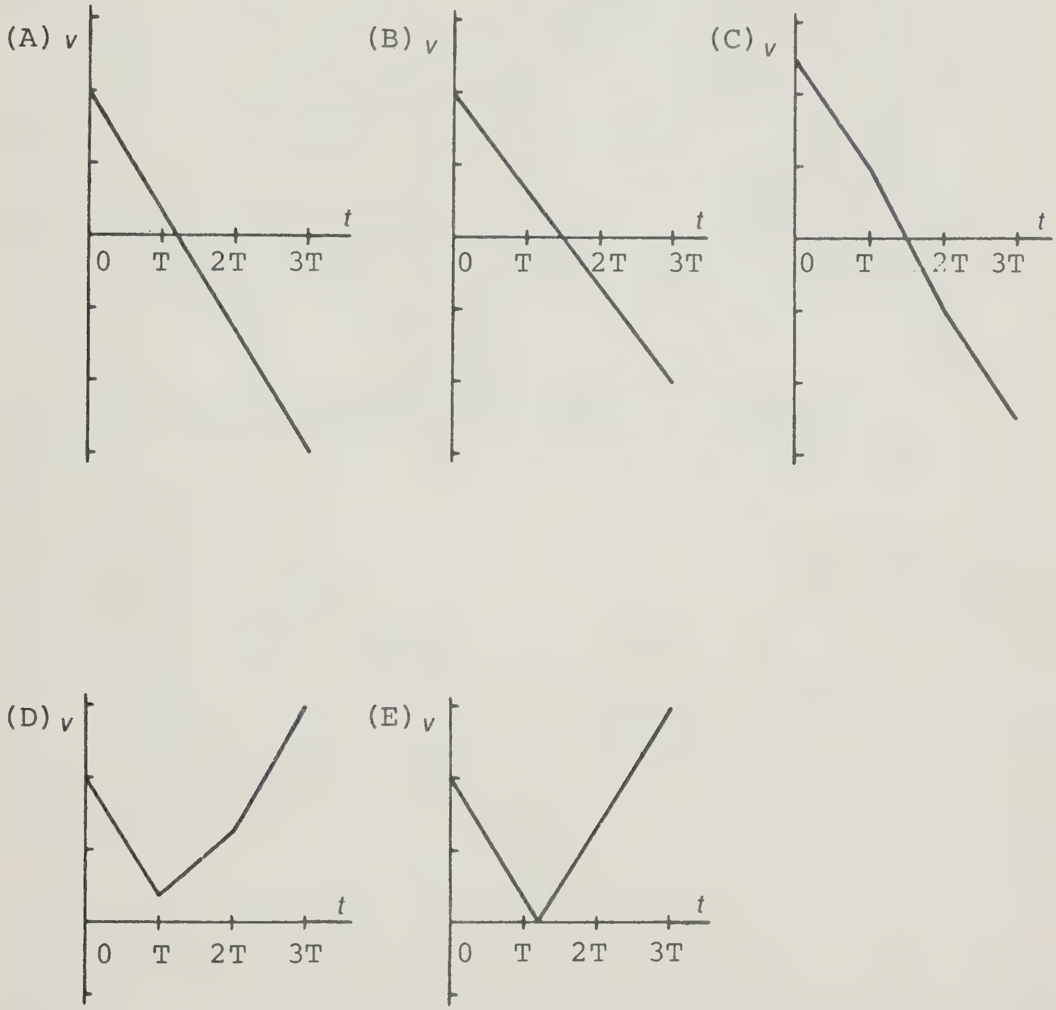
–

***

The velocity vectors w, x, y, z, of a particle executing straight line motions are shown below at four successive, equally spaced time intervals.



Which one of the graphs shown below could represent the velocity-time graph for the particle's motion?



3

S17A
I.2.a
S17C
I.3.a

14

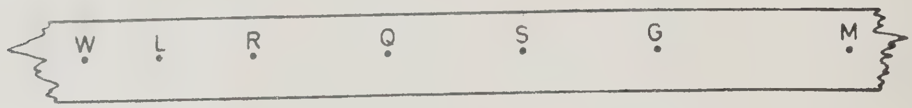
D3

(B)

\-

**

A tape from a laboratory experiment has the appearance shown below. The dots were made by a vibrator with a steady frequency of 20 Hz.



The total elapsed time between dot W and dot M is

(A) 6.0 s

(B) 0.30 s

(C) 0.35 s

(D) 3.0 s

(E) 3.5 s

4 Consider the following graphs:

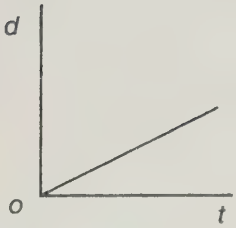
S17A
I.2.a
S17C
I.3.a

15

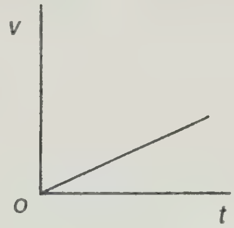
A11

(E)

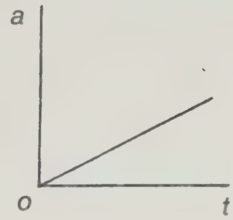
**
**



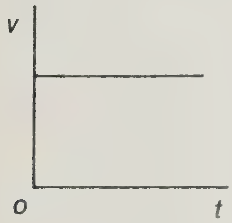
(I)



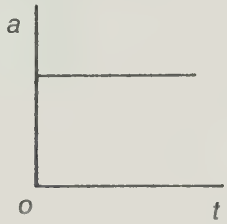
(II)



(III)



(IV)



(V)

Which of these represent(s) motion at constant speed?

(A) IV only

(B) IV and V only

(C) I, II and III only

(D) I and II only

(E) I and IV only

5

S17A
I.2.a
S17C
I.3.a

S 15

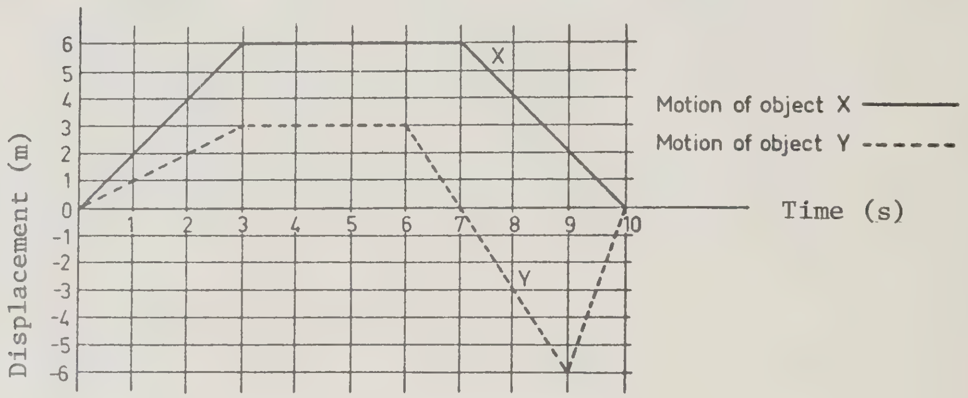
A7

(E)

\-

***

Two objects, X and Y, are moving along a straight line. The graph below shows the displacements of both objects during a 10 s time interval. Both objects begin moving north from the same starting point at time $t = 0$.



The total <u>distance</u> travelled by object Y during the 10 s interval is

(A) zero

(B) 3 m

(C) 9 m

(D) 12 m

(E) 18 m

6

S17A
I.2.a
S17C
I.3.a

16

A11

(A)

**
*

This displacement-time graph shows an example of

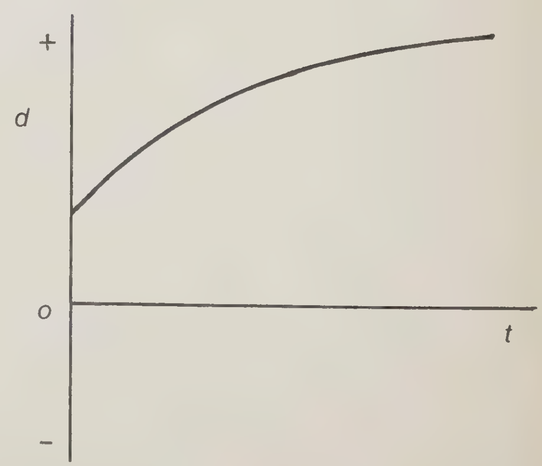
(A) negative acceleration

(B) positive acceleration

(C) zero acceleration

(D) negative velocity

(E) increasing velocity



7

S17C
I.3.a

16

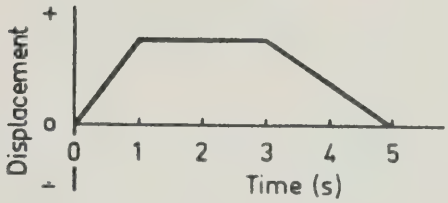
A7
A11

(A)

-

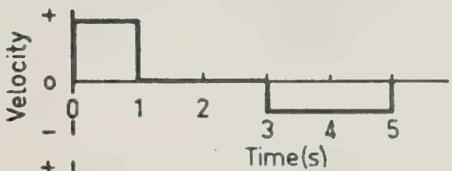
**

The following graph represents a displacement-time graph for an object during a 5 s time interval.

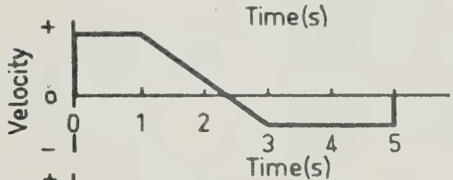


Which one of the following graphs of velocity versus time would best represent the velocity of the object during the same time interval?

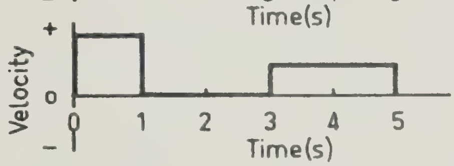
(A)



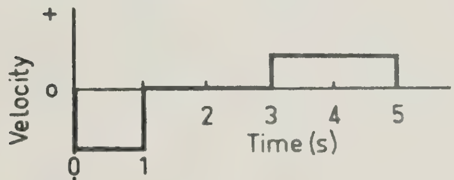
(B)



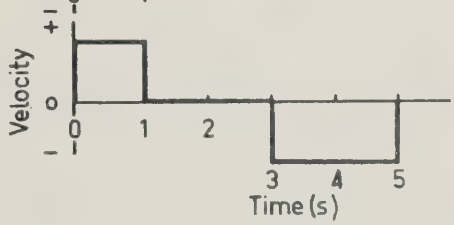
(C)



(D)



(E)



8

S17A
I.2.a
S17C
I.3.a

16

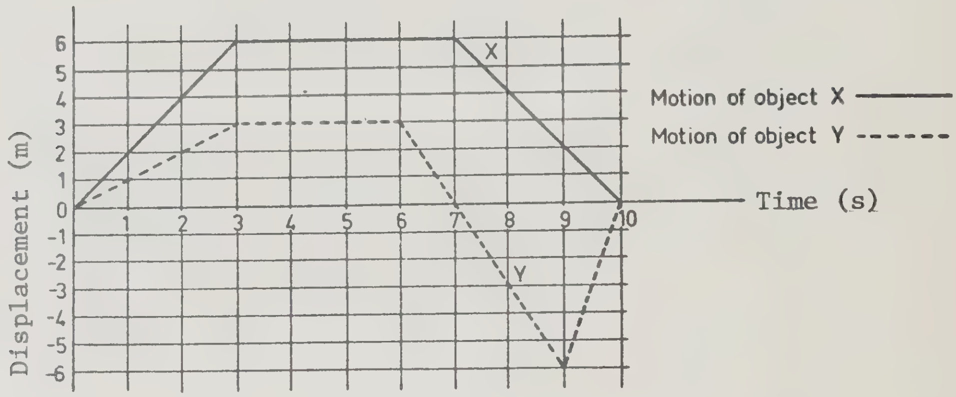
F1
A11
A7

(C)

\-

*

Two objects, X and Y, are moving along a straight line. The graph below shows the displacements of both objects during a 10 s time interval. Both objects begin moving north from the same starting point at time $t = 0$.



At time $t = 8$ s, the displacement of object Y relative to object X is

(A) 1 m south

(B) 3 m south

(C) 7 m south

(D) 4 m north

(E) 7 m north

9

S17A
I.2.a
S17C
I.3.a

16

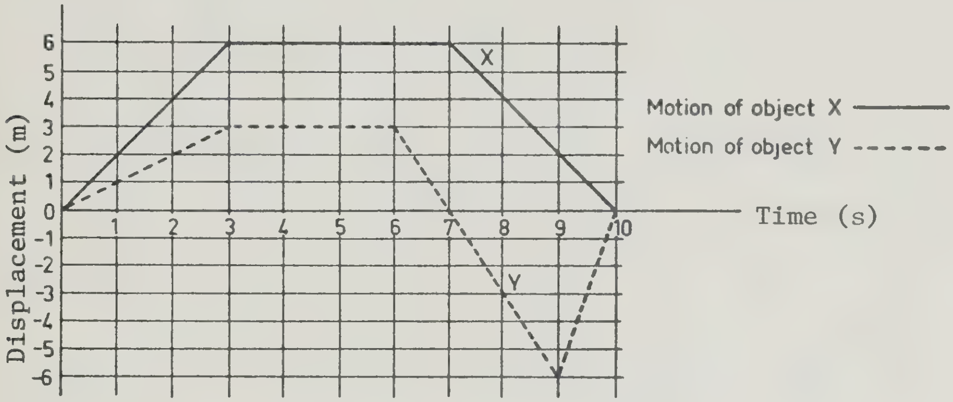
F1
A11
A7

(D)

-

**

Two objects, X and Y, are moving along a straight line. The graph below shows the displacements of both objects during a 10 s time interval. Both objects begin moving north from the same starting point at time $t = 0$.



At time $t = 8$ s, the velocity of object Y relative to object X is

(A) zero

(B) 1 m/s north

(C) 2 m/s north

(D) 1 m/s south

(E) 2 m/s south

10

S17C
I.3.a

16

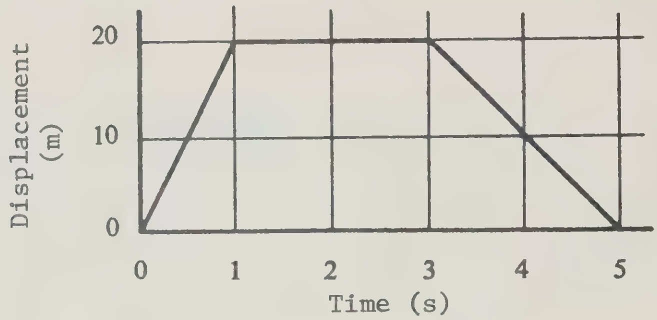
A11
A7

(E)

\-

***

Select from the following statements the one that is true for the graph below.



(A) The acceleration during the first second is uniform and greater than 0.

(B) The velocity between t = 1 s and t = 3 s is uniform and greater than 0.

(C) The average speed is always equal to the magnitude of the average velocity.

(D) The distance travelled between t = 1 s and t = 2 s is greater than the distance travelled between t = 0 s and t = 1 s.

(E) None of the above statements is true.

11

S17A
I.2.a
S17C
I.3.a

16

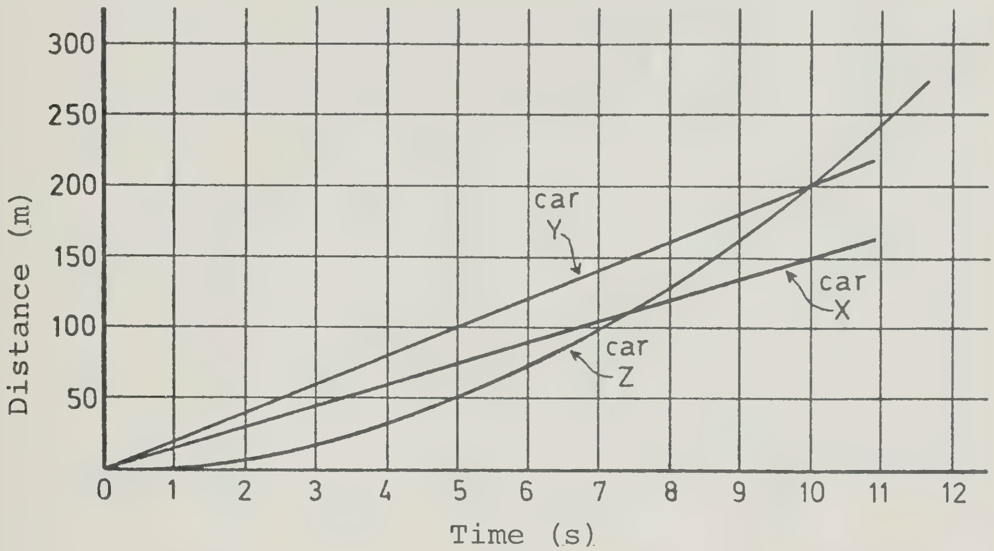
A11
A7
F1

(A)

-

*

The graph below shows the motion of three cars, X, Y, and Z along a straight road. Car X is travelling at the speed limit while car Y is travelling at a speed in excess of the limit. The two cars pass a stationary police car Z at time $t = 0$ and continue with uniform speed. The car Z immediately gives chase with a constant acceleration until it reaches car Y.



Car Y is exceeding the speed limit by

(A) 5 m/s

(B) 10 m/s

(C) 15 m/s

(D) 20 m/s

(E) 50 m/s

12

S17C
I.3.a

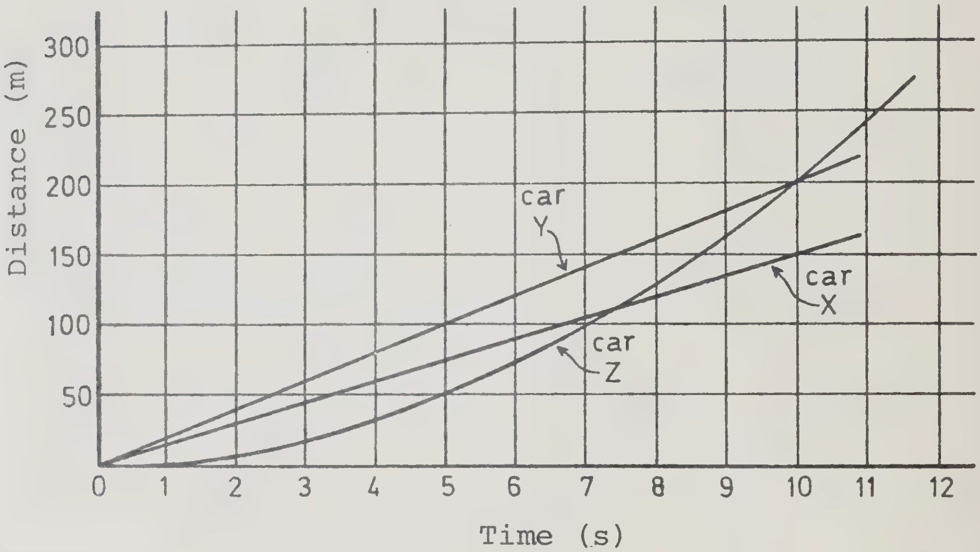
16

A11
A7
F1

(D)

-
***

The graph below shows the motion of three cars, X, Y, and Z along a straight road. Car X is travelling at the speed limit while car Y is travelling at a speed in excess of the limit. The two cars pass a stationary police car Z at time $t = 0$ and continue with uniform speed. The car Z immediately gives chase with a constant acceleration until it reaches car Y.



The speed of the police car at the instant it overtakes car Y is

(A) 10 m/s

(B) 20 m/s

(C) 30 m/s

(D) 40 m/s

(E) 50 m/s

13

S17C
I.3.a

16

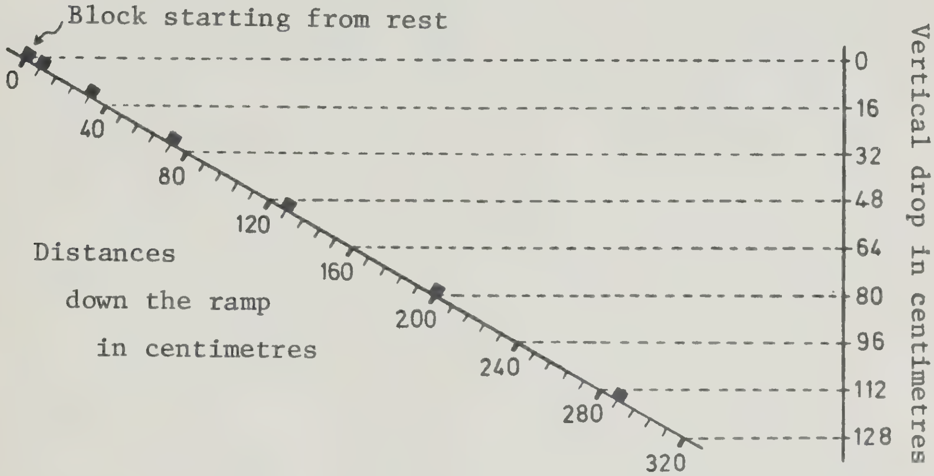
D3
F1

(D)

-

***

The multiflash picture below was taken of a 2 kg block sliding with uniform acceleration down a frictionless ramp. The multiflash operated at a rate of five flashes per second (g = 10 m/s^2).



The instantaneous speed of the block at the 200 cm mark on the ramp is

(A) 40 cm/s

(B) 100 cm/s

(C) 200 cm/s

(D) 400 cm/s

(E) 800 cm/s

14

S17A
I.2.a
S17C
I.3.a

16

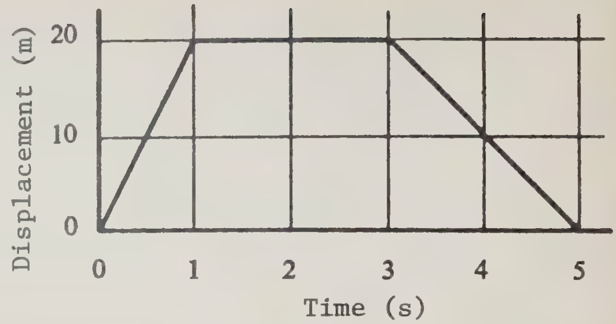
F1
A11
A7

(A)

-

***

The magnitude of the average velocity during the first 4 s based on the graph is



(A) 2.5 m/s

(B) 5.0 m/s

(C) 7.5 m/s

(D) 10.0 m/s

(E) 65.0 m/s

15

S17C
I.3.a

S 16

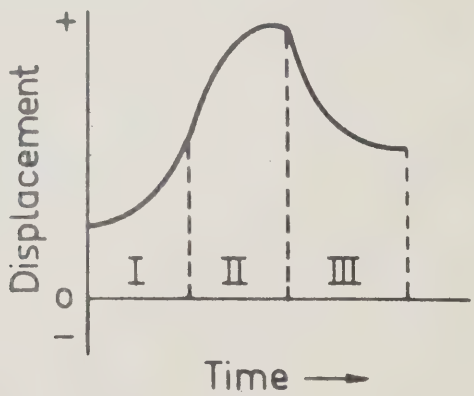
D7
A7

(E)

-

***

The displacement-time graph for an object travelling along a straight line is shown in the diagram. For which of the sections I, II and III is the acceleration positive?



(A) Section I only

(B) Section II only

(C) Section III only

(D) Sections I and II only

(E) Sections I and III only

16

S17A
I.2.a
S17C
I.3.a

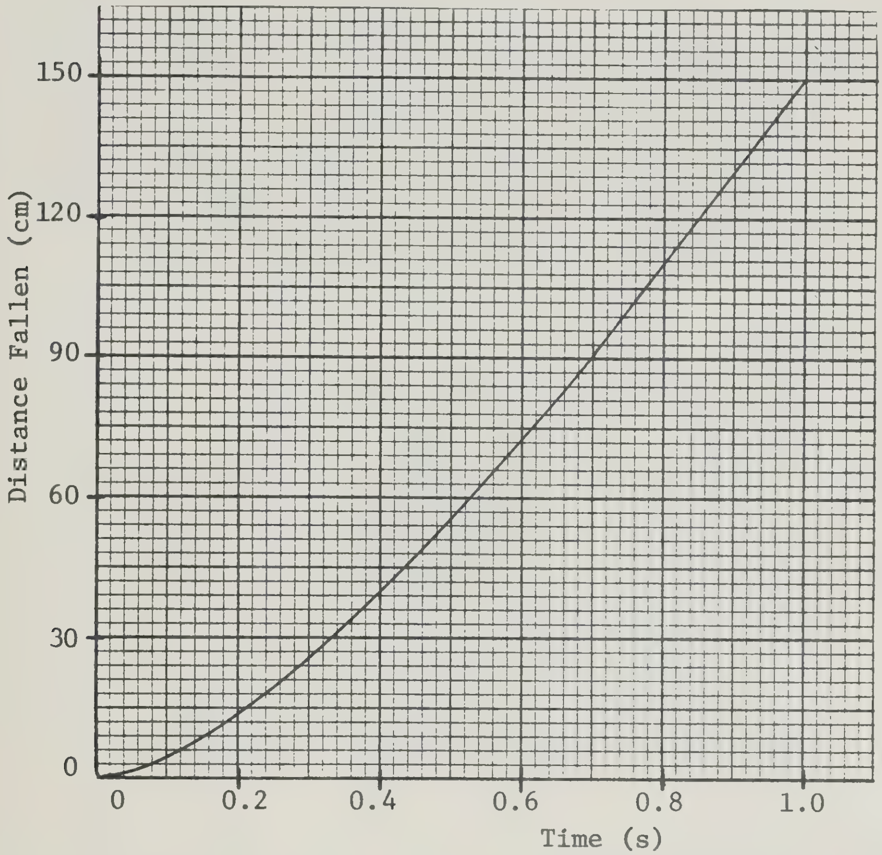
16

F1
D3

(D)

***
***

The graph below was drawn from data obtained when a styrofoam ball was dropped from rest.



The maximum speed of the ball was

(A) 20 cm/s

(B) 70 cm/s

(C) 150 cm/s

(D) 200 cm/s

(E) 1000 cm/s

17

S17C
I.3.a

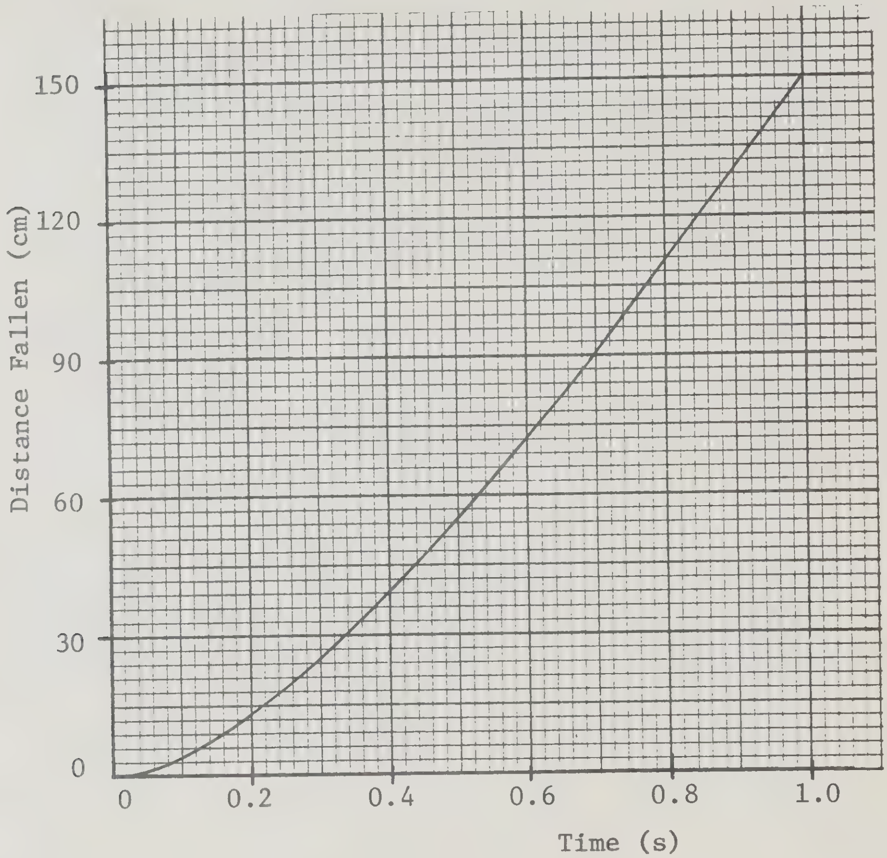
16

F1
D3

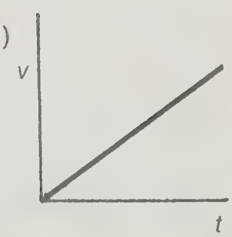
(C)

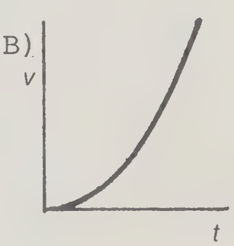
***
***

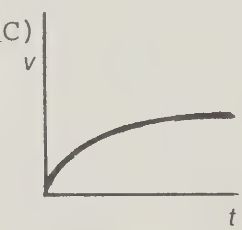
The graph below was drawn from data obtained when a styrofoam ball was dropped from rest.

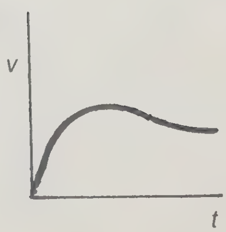


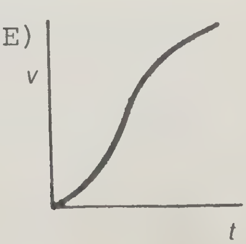
Of the following graphs, the one which best represents the speed of the ball as a function of time is

(A)


(B)


(C)


(D)


(E)


18

S17A
I.2.a
S17C
I.3.c

S 16

F2
A8

(C)

-
**

The geological past is often divided into eras and periods according to the chart below.

Era	Period	Years elapsed to present
		present
Cenozoic	Quaternary	1.7×10^6
	Tertiary	5.5×10^7
Mesozoic	Cretaceous	1.2×10^8
	Jurassic	1.3×10^8
	Triassic	1.5×10^8
Paleozoic	Carboniferous	2.7×10^8
	Devonian	3.0×10^8
	Silurian	3.5×10^8
	Ordovician	3.8×10^8
	Cambrian	4.7×10^8
Proterozoic	Pre-Cambrian	1.0×10^9

Certain deposits at sea level at the end of the Triassic period were subsequently lifted to their present elevation of approximately 2000 m above sea level. If the time rate of elevation has been constant, the average rate of uplifting must have been about

(A) 1.5×10^{-11} m/a

(B) 6.5×10^{-7} m/a

(C) 1.5×10^{-5} m/a

(D) 6.5×10^{-4} m/a

(E) 1.5×10^{-1} m/a

19 A particle moves in a straight line as described in the graph below.

S17C
I.3.b

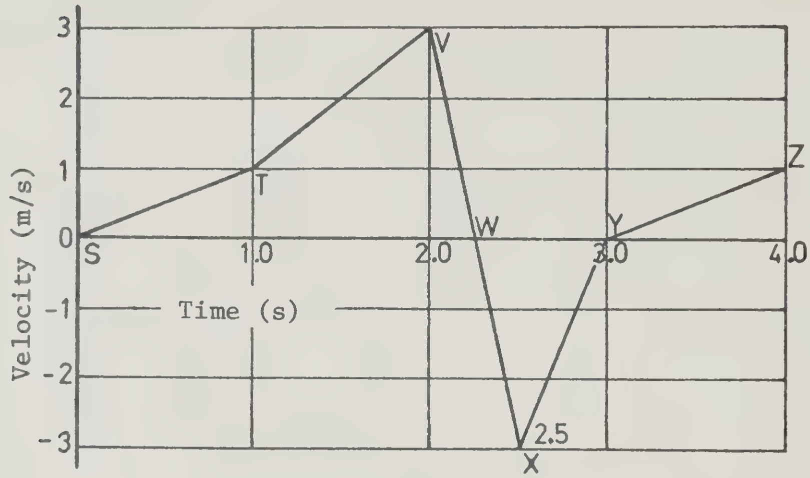
17

D3
F1

(D)

\-

**



During which part of the motion is the positive acceleration of the particle greatest?

(A) ST

(B) TV

(C) VX

(D) XY

(E) YZ

20 This graph shows the speed of a 3 kg mass as a function of time.

S17A
I.2.a
S17C
I.3.b

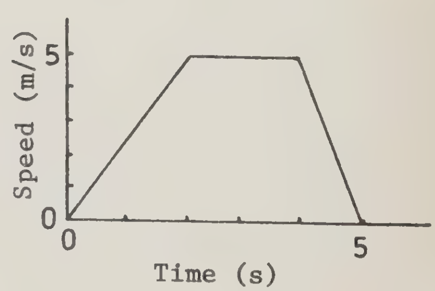
17

D3
A7

(A)

\-

***



The average acceleration over the period 0 to 5 s is

(A) 0 m/s^2

(B) 1.0 m/s^2

(C) 2.5 m/s^2

(D) 1.25 m/s^2

(E) 5.0 m/s^2

21 Consider the following graphs.

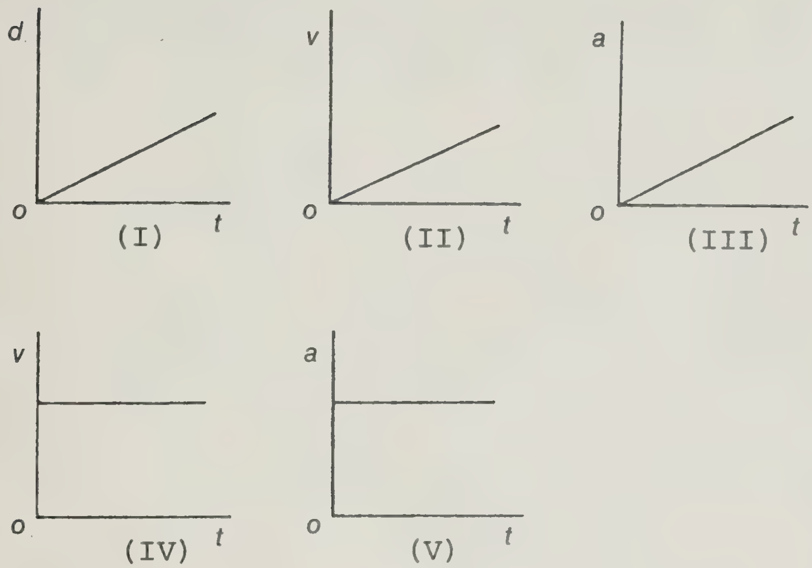
S17C
I.3.b

17

All

(E)

**
**



Which of these graphs represents motion with uniform non-zero acceleration?

(A) I and III only

(B) I and IV only

(C) I, II and III only

(D) II and IV only

(E) II and V only

22

S17C
I.3.b

17

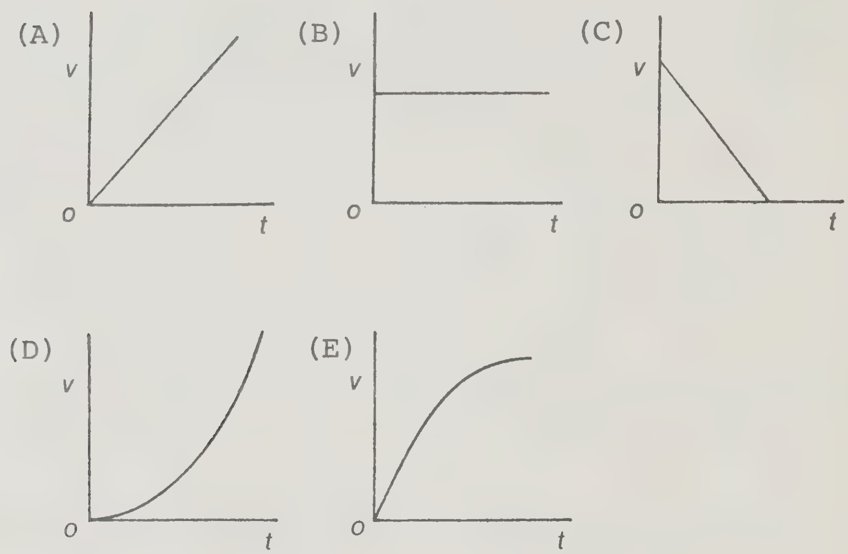
All

(C)

***
**

An object is thrown vertically up into the air, and its speed is recorded from the moment it leaves the hand until it reaches maximum height.

Which one of the following graphs represents the object's speed (v) as a function of time (t)?



23

S17A
I.2.a
S17C
I.3.b

17

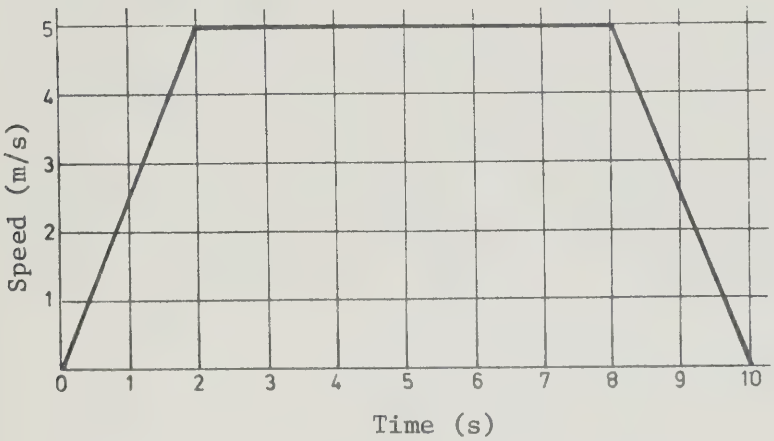
D3
A11
A7

(C)

\-

*

An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and the elevator moves as shown in the speed-time graph below.



The acceleration of the elevator during the first two seconds of motion is

(A) 10 m/s^2

(B) 5.0 m/s^2

(C) 2.5 m/s^2

(D) 2.0 m/s^2

(E) 0 m/s^2

24

S17C
I.3.b

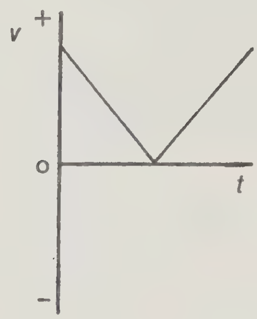
17

F1

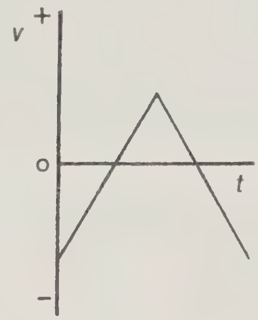
(C)

***
**

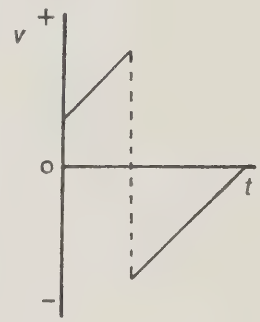
Which of the following graphs best represents the velocity-time graph for a ball which is thrown towards the floor and bounces back up? (Neglect friction and use positive for the downward direction.)



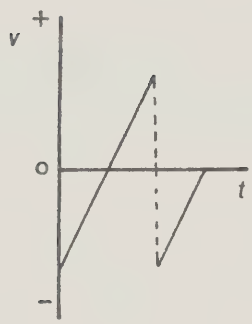
(A)



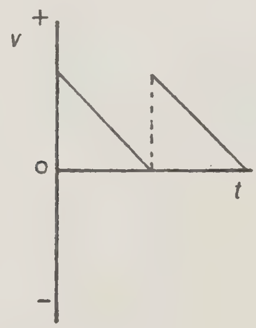
(B)



(C)



(D)



(E)

25

S17C
I.3.c

17

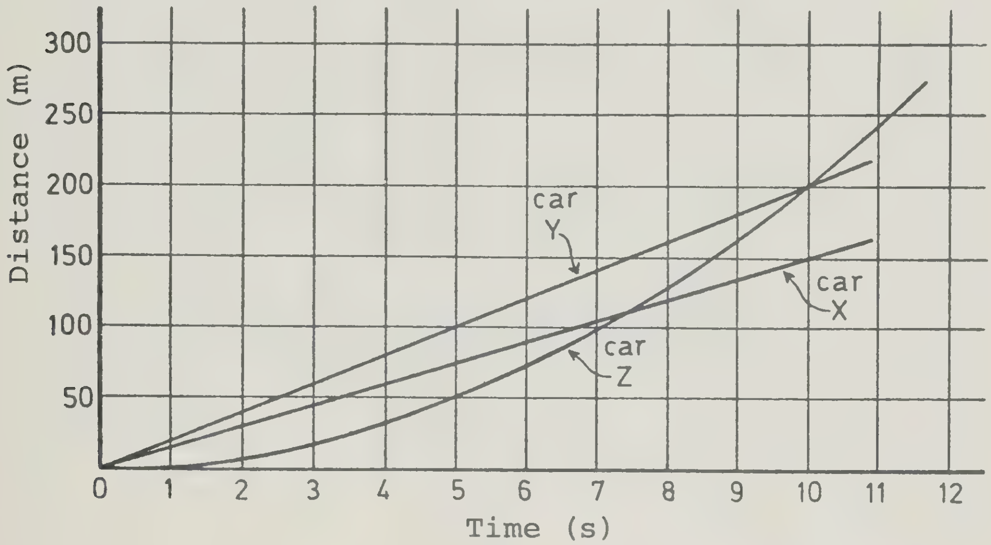
F1
A11
A7

(B)

-

***

The following graph shows the motion of three cars, X, Y and Z along a straight road. Car X is travelling at the speed limit while car Y is travelling at a speed in excess of the limit. The two cars pass a stationary police car Z at time $t = 0$ and continue with uniform speed. The car Z immediately gives chase with a constant acceleration until it reaches car Y.



The acceleration of the police car is

(A) 2 m/s^2

(B) 4 m/s^2

(C) 6 m/s^2

(D) 8 m/s^2

(E) 10 m/s^2

26 The motion of an object travelling in a straight line is represented by the following graph.

S17C
I.3.b

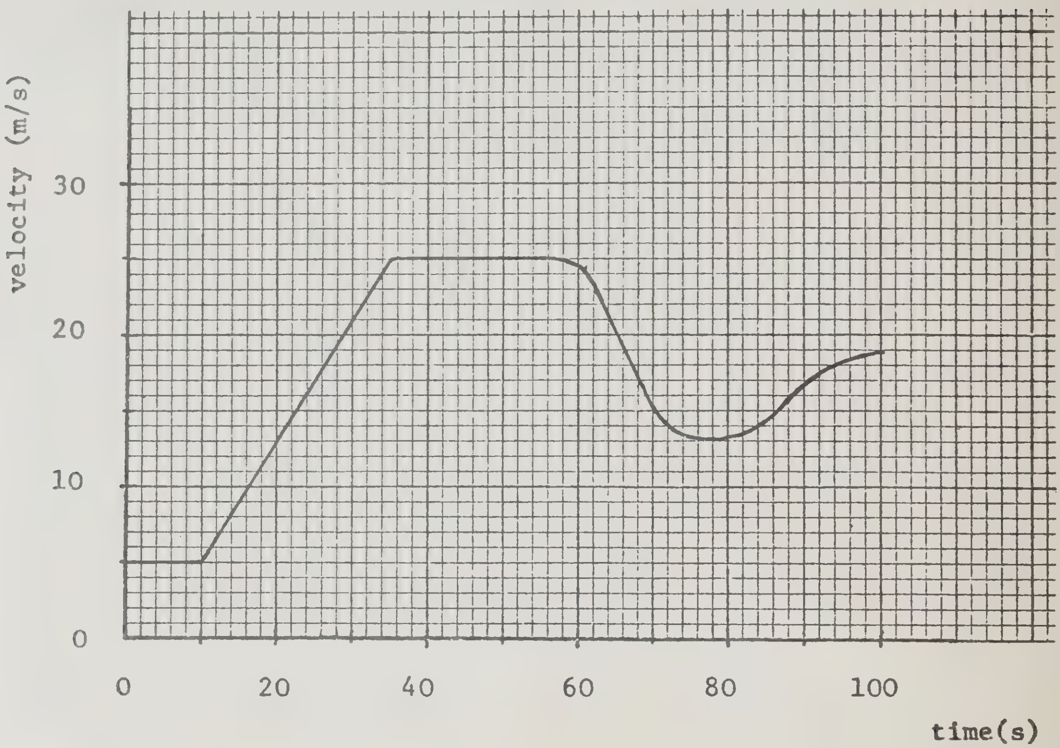
17

F1
All

(B)

-

**



In the above graph, at time = 65 s, the magnitude of the instantaneous acceleration of the object was most nearly

(A) $-2\ m/s^2$

(B) $-1\ m/s^2$

(C) $0\ m/s^3$

(D) $+1\ m/s^2$

(E) $+2\ m/s^2$

27

S17C
I.3.b

17

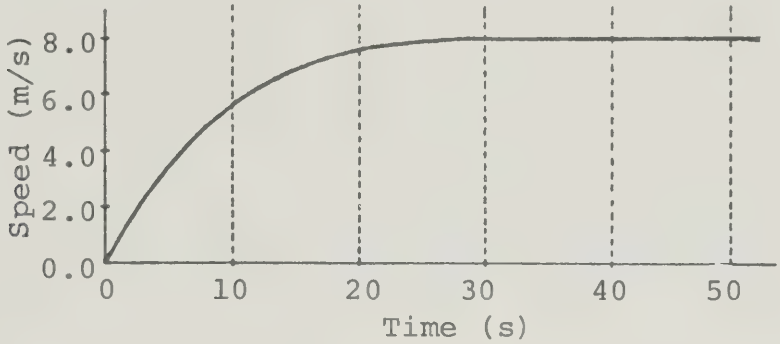
F1
A7
A11

(B)

-

***

A locomotive has a mass of 1.0×10^5 kg. The engineer operates it, when no cars are being pulled, in such a way that he exerts the maximum possible force at any speed. The force depends on the speed. The speed of the locomotive, as a function of time, under these conditions, is shown in the graph below.



The acceleration of the locomotive when it is travelling at 5.0 m/s is closest to

(A) 0.0 m/s^2

(B) 0.3 m/s^2

(C) 0.5 m/s^2

(D) 1.0 m/s^2

(E) 5.0 m/s^2

28

S17C
I.3.b

S 17

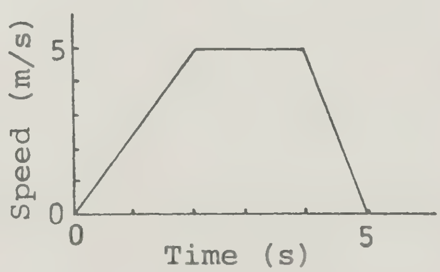
D3
A7

(C)

-

**

This graph shows the speed of a 3 kg mass as a function of time.



The average speed over the period 0 to 5 s is

(A) 0 m/s

(B) 2.5 m/s

(C) 3.5 m/s

(D) 5.0 m/s

(E) 7.5 m/s

29

S17C
I.4.f

S 17

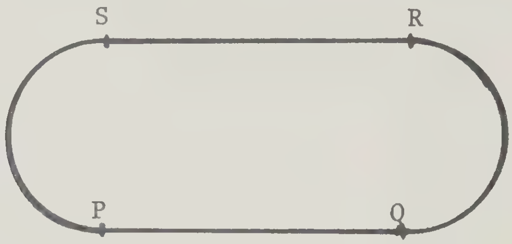
A11
A8
F1

(A)

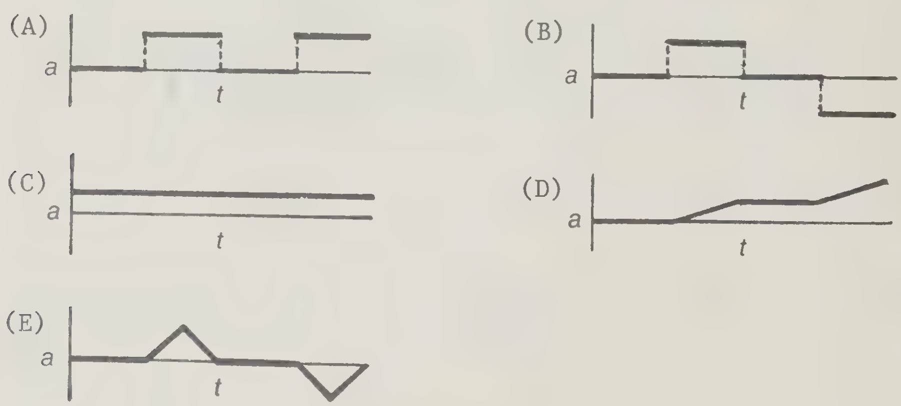
-

***

A racetrack, shown in the figure below, is such that the lengths of its segments PQ, QR, RS and SP are equal. Arcs QR and SP are semicircles.



A runner runs once around the track, starting from P in the order PQRSP, at constant speed. A graph of the magnitude of the runner's acceleration a, plotted against time t, during one lap would appear most like



30

S17C
I.3.b

18

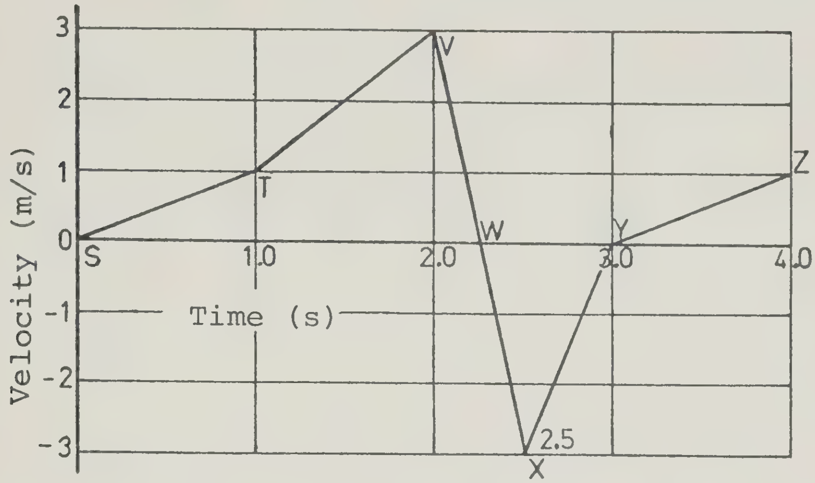
D3
A7
F1

(B)

-

***

A particle moves in a straight line as described in the graph below.



At what point during the four seconds is the particle's displacement from its starting position S the greatest?

(A) V

(B) W

(C) X

(D) Z

(E) None of these

31

S17C
I.3.b

18

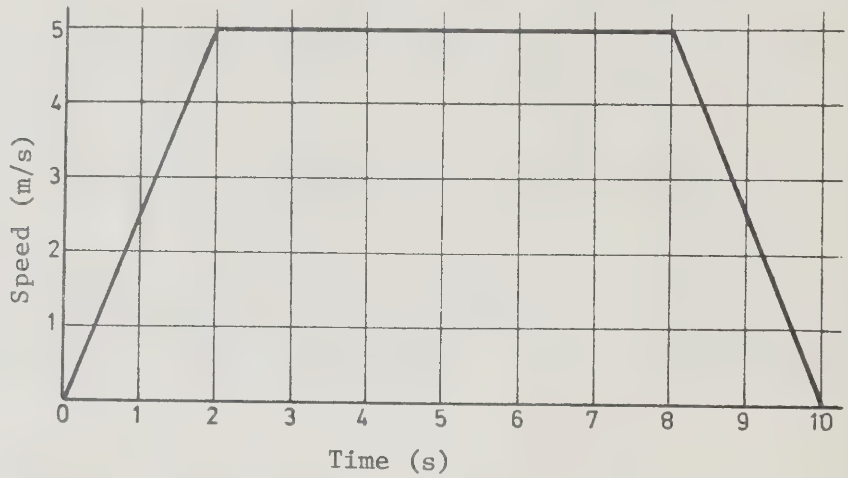
D3
A11
A7

(B)

-

**

An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and the elevator moves as shown in the speed-time graph below.



The distance travelled from the basement to the tenth floor is

(A) 50 m

(B) 40 m

(C) 35 m

(D) 30 m

(E) 25 m

32 Acceleration is defined as

S17A
I.2.a
S17C
I.3.b

19

A2

(D)

**
-

(A) rate of change of displacement with time

(B) speed divided by time

(C) change in velocity

(D) rate of change of velocity with time

(E) a speeding up

33 The graph below shows the speed as a function of time for an automobile with a mass of 1.5×10^3 kg.

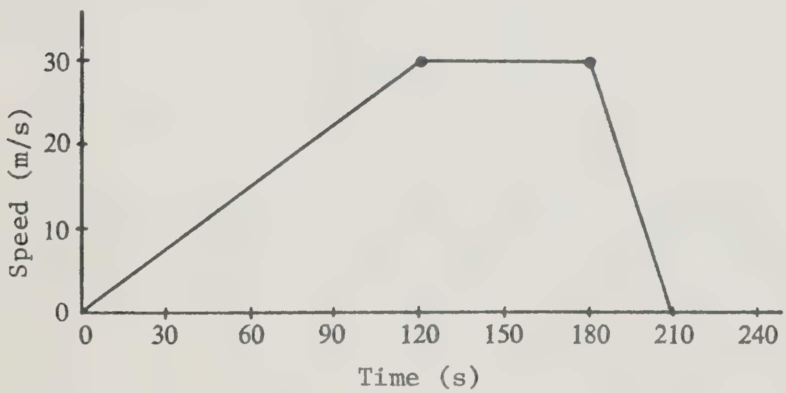
S17A
I.2.a
S17C
I.3.b

19

A8
F1
A11

(A)

-
*



The automobile's acceleration at the end of 60 s was

(A) 0.25 m/s^2

(B) 2.5 m/s^2

(C) 15 m/s^2

(D) 4.0 m/s^2

(E) $4.5 \times 10^2 \text{ m/s}^2$

34

S17A
I.2.a
S17C
I.3.b

19

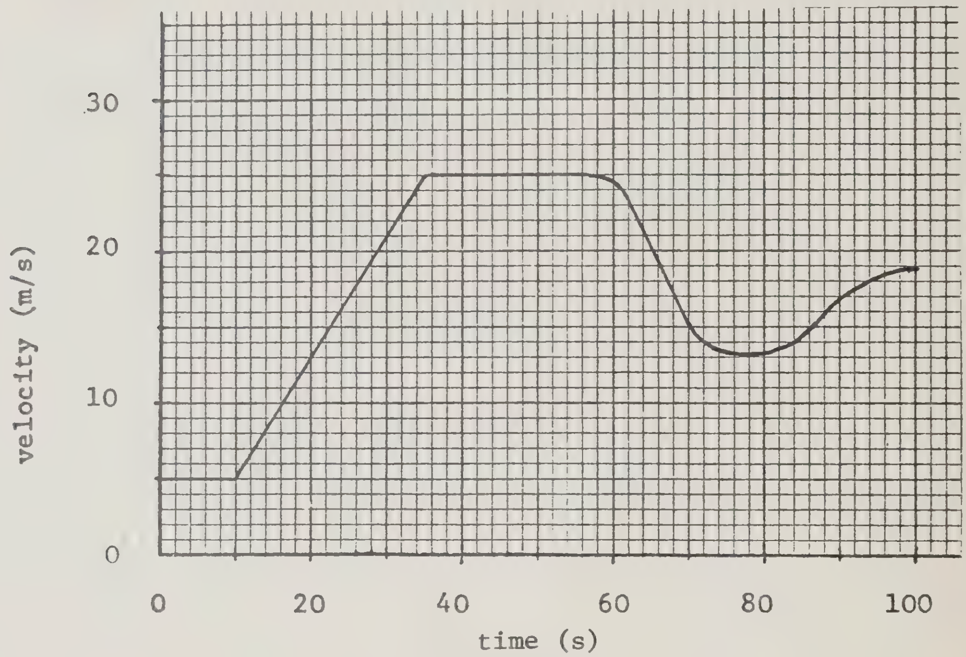
F1
All

(B)

\-

**

The motion of an object travelling in a straight line is represented by the following graph:



In the above graph what was the magnitude of the acceleration of the object during the 25 s time interval between 10 s and 35 s?

(A) $0.64\ m/s^2$

(B) $0.80\ m/s^2$

(C) $1.0\ m/s^2$

(D) $1.4\ m/s^2$

(E) $19\ m/s^2$

35 An airplane is flying at a constant speed of 500 km/h. It executes a slow turn that changes its direction of travel from north through east to south. If the turn takes 40 s, the airplane's average acceleration is

S17C
I.4.f

19

F1
A8

(E)

-
***

(A) 12.5 (km/h)/s [N]

(B) 12.5 (km/h)/s [S]

(C) 12.5 (km/h)/s [E]

(D) 25.0 (km/h)/s [N]

(E) 25.0 (km/h)/s [S]

36 Displacement can be obtained from

S17A
I.2.a
S17C
I.3.b

20

A7
A3

(D)

*
*

(A) the slope of an acceleration-time graph

(B) the slope of a velocity-time graph

(C) the area under an acceleration-time graph

(D) the area under a velocity-time graph

(E) the slope of a displacement-time graph

37

S17A
I.2.a
S17C
I.3.c

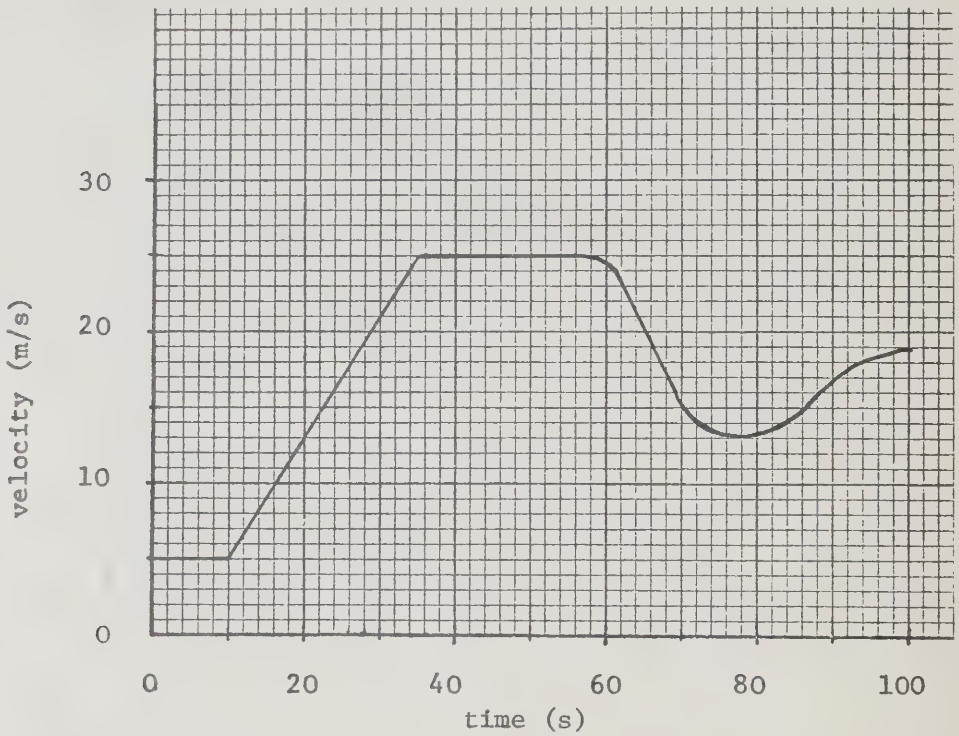
20

F1
All

(D)

***
***

The motion of an object travelling in a straight line is represented by the following graph.



What was the magnitude of the average velocity of the object during the 25 s time interval between 10 s and 35 s?

(A) 0.80 m/s

(B) 5.0 m/s

(C) 10 m/s

(D) 15 m/s

(E) 25 m/s

38

S17A
I.2.a
S17C
I.3.c

20

F1

(E)

***
**

A boat is able to move through still water with a maximum speed of 20 m/s. The boat makes a trip to a town 3 km downstream and then back to its starting point. The river flows at a constant speed of 5 m/s.

The minimum time required for the round trip is:

(A) 120 s

(B) 150 s

(C) 200 s

(D) 300 s

(E) 320 s

39

S17C
I.3.c

21

A1

(B)

-
***

A car moves with uniform acceleration a, through displacement s, in time t. During this time its velocity changes from v_0 to v_1.

Which one of the following statements is true?

(A) At time $\frac{t}{2}$, the car has travelled distance $\frac{s}{2}$.

(B) At time $\frac{t}{2}$, the car travels with velocity $\frac{v_0 + v_1}{2}$.

(C) At distance $\frac{s}{2}$, the velocity of the car is $\frac{v_0 + v_1}{2}$.

(D) At time $\frac{t}{2}$, the velocity is $\frac{v_0 + at}{2}$.

(E) At distance $\frac{s}{2}$, the velocity is $\frac{v_0 + at}{2}$.

40

S17C
I.3.c

21

B5
F1

(B)

-

***

Using $d = \frac{1}{2}gt^2$, taking $g = 10$ m/s^2, and neglecting air resistance, the best estimate of the time required for an object dropped from the top of a fifteen-story apartment building to reach the ground is

(A) 2 s

(B) 3 s

(C) 5 s

(D) 7 s

(E) 10 s

41

S17C
I.3.c

21

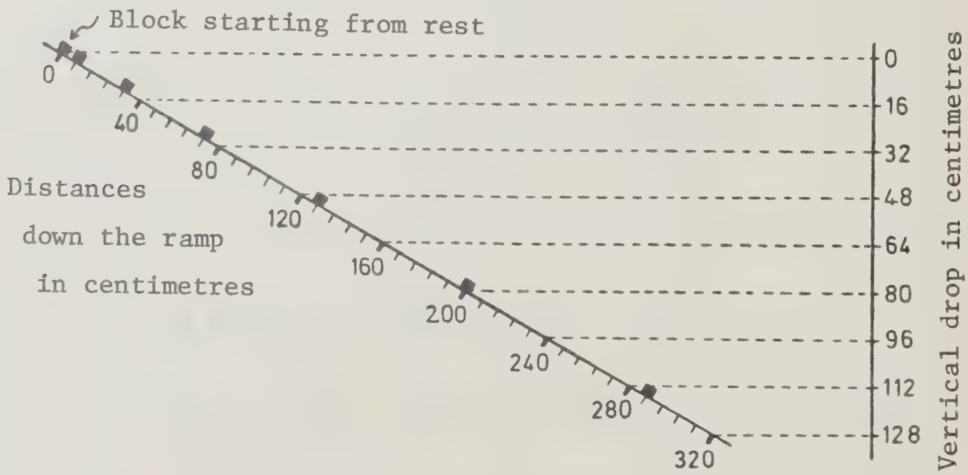
D3
F1

(D)

-

***

The multiflash picture below was taken of a 2 kg block sliding with uniform acceleration down a frictionless ramp. The multiflash operated at a rate of five flashes per second ($g = 10$ m/s^2).



The acceleration of the block down the ramp is

(A) 40 cm/s^2

(B) 100 cm/s^2

(C) 200 cm/s^2

(D) 400 cm/s^2

(E) 800 cm/s^2

42

S17C
I.4.f

21

F1

(D)

-

***

A destroyer is sailing due east at 14 km/h. One hour later it has turned and is now sailing due south at 48 km/h. What is the magnitude of its average acceleration over this period of time?

(A) 34 km/h

(B) 34 km/h^2

(C) 46 km/h^2

(D) 50 km/h^2

(E) 62 km/h^2

43

S17A
I.2.a
S17C
I.3.c

21

F1

(B)

***
**

An object is thrown vertically upward at 35 m/s. Its velocity after 5 s if $g = 10\ m/s^2$ is

(A) 7 m/s up

(B) 15 m/s down

(C) 15 m/s up

(D) 85 m/s down

(E) 85 m/s up

44

S17C
I.3.c

21

F1

(D)

**
**

A body with an initial velocity of 12 m/s west experiences an acceleration of 4 m/s^2 west for a period of 3 s. During this time it travels a distance of

(A) 12 m

(B) 24 m

(C) 36 m

(D) 54 m

(E) 144 m

45

S17A
I.2.a
S17C
I.3.c

21

F1

(D)

**
*

A car moving at an initial velocity of 100 m/s north has an acceleration of 10 m/s^2 south. Its velocity after 6 s will be

(A) 160 m/s north

(B) 60 m/s north

(C) 60 m/s south

(D) 40 m/s north

(E) 40 m/s south

46

S17C
I.3.c

21

F1
A3

(E)

**
*

How far would a car travel in 6.0 s if its initial speed was 2.0 m/s and if it accelerated at 2.0 m/s^2?

(A) 12 m

(B) 14 m

(C) 24 m

(D) 36 m

(E) 48 m

47

S17C
I.3.c

21

F1
A3

(B)

**
**

How long would it take a truck to increase its speed from 10 m/s to 30 m/s if it does so with uniform acceleration over a distance of 80 m?

(A) 2.0 s

(B) 4.0 s

(C) 5.0 s

(D) 8.0 s

(E) the time cannot be calculated since the acceleration is not given

48 A car initially at rest travels a distance of 20.0 m in 4.0 s with uniform acceleration. The magnitude of the acceleration of the car in metres per second squared is

S17C
I.3.c

21

F1
A3

(C)

***
**

(A) 0.4

(B) 1.3

(C) 2.5

(D) 5.0

(E) 10

49 An object is thrown straight up from ground level with a speed of 50 m/s. Its distance above ground 1.0 s after being thrown is

S17C
I.3.c

21

F1
A3

(D)

***
***

(A) 25 m

(B) 30 m

(C) 40 m

(D) 45 m

(E) 50 m

50 An object falls freely from rest. If in the first second it falls a distance h, how far will it fall during the next second?

S17C
I.3.c

21

F1
A8

(C)

-
***

(A) h

(B) $2h$

(C) $3h$

(D) $4h$

(E) $5h$

51

S17C
I.3.c

21

F1
A3

(E)

*
-

An object is thrown straight up from ground level with a speed of 50.0 m/s. Its distance above ground 6.00 s after being thrown is

(A) 0.00 m

(B) 270 m

(C) 330 m

(D) 480 m

(E) none of the above

52

S17C
I.3.b

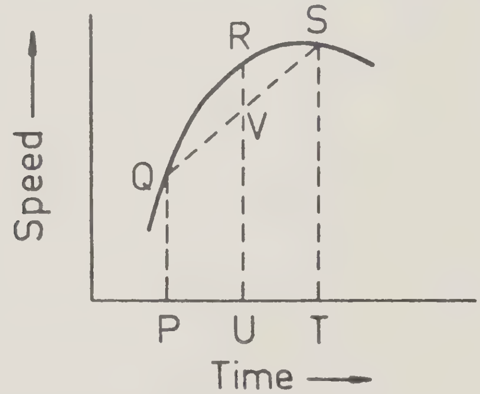
S 21

D3
A11
A7

(E)

-
***

The motion of an object, which is moving in a straight line, is represented by the speed-time graph shown in the diagram.



Which one of the following best represents the average speed of the object during the time interval PT?

(A) UR

(B) $\frac{PQ + TS}{2}$

(C) $\frac{PQ + UR + TS}{3}$

(D) $\frac{\text{Area } PQVST}{\text{Time } PT}$

(E) $\frac{\text{Area } PQRST}{\text{Time } PT}$

53

S17A
I.2.a
S17C
I.3.c

S 21

F1
D1

(C)

-
**

A radar transmitter sends out a pulse which is reflected from the moon's surface. The signal returns 2.7 s after it is sent. What is the best estimate of the moon's distance from the earth if light travels at 3×10^8 m/s?

(A) 0.55×10^8 m

(B) 1.1×10^8 m

(C) 4.0×10^8 m

(D) 8.1×10^8 m

(E) 16.2×10^8 m

MOTION IN A PLANE AND VECTORS

1

S17C
I.4.a

23

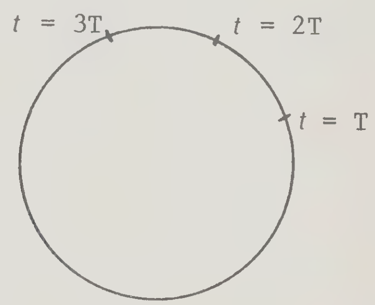
A2

(D)

-

*

A proton situated in a magnetic field is observed to travel in a circular path. The positions of the proton at times T, 2T and 3T are shown in the figure below.



Which vector best represents the displacement of the proton from the centre of the circle at t = 2T?

(A) (B) (C) (D) (E)

2

S17C
I.4.f

24

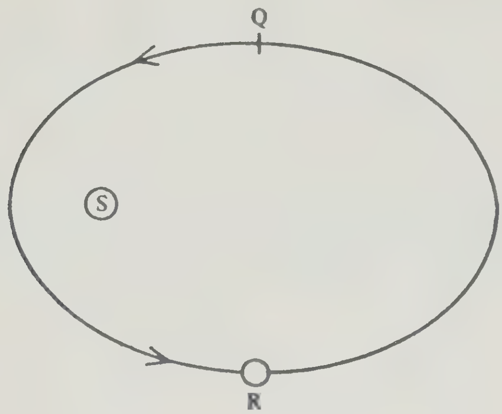
A8
A11

(A)

-

***

A planet moves in an eliptical orbit around a sun as shown below.



The direction of the vector representing the average velocity of the planet during the portion QR of its orbit is

(A) ↓ (B) ↑ (C) → (D) ↗ (E) ↖

3

S17C
I.4.b

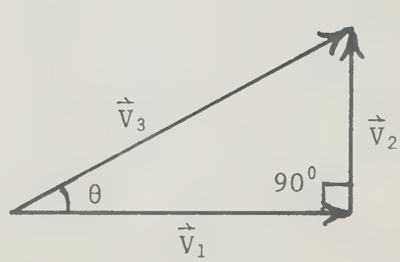
24

A7

(B)

**
-

The vector $\vec{V}_3$ in the diagram at the right is equivalent to



(A) $\vec{V}_1 - \vec{V}_2$

(B) $\vec{V}_1 + \vec{V}_2$

(C) $\vec{V}_2 - \vec{V}_1$

(D) $\vec{V}_1{}^2 + \vec{V}_2{}^2$

(E) $\vec{V}_1 \cos\theta$

4

S17C
I.4.b

24

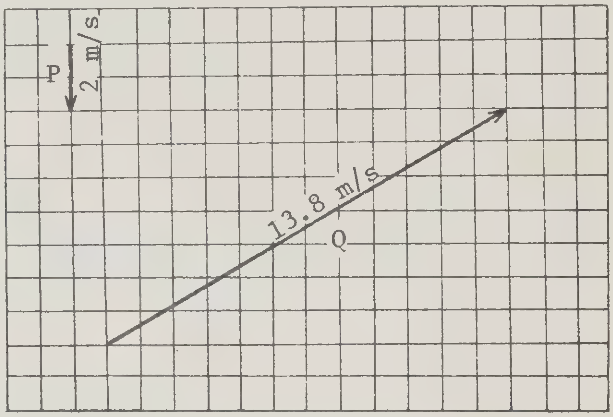
A7

(B)

-

**

Vectors P and Q in the grid below represent velocities. Each side of each little square in the grid represents a speed of 1 m/s.



Let vector P represent one velocity component of a particle. Let vector Q represent the other velocity component of the same particle. The resultant speed of the particle is

(A) 11.8 m/s

(B) 13 m/s

(C) 13.8 m/s

(D) 15 m/s

(E) 15.8 m/s

5

S17A
I.2.a
S17C
I.4.c

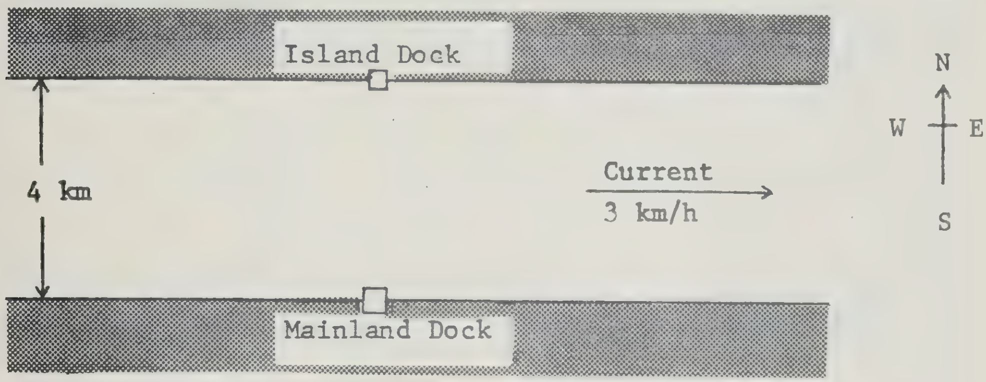
24

F1
A3

(B)

**
**

A man lives on an island 4 km offshore, across a channel which has a 3 km/h current when the tide is running. On a dark night, with the tide running, he rows from the mainland dock toward the island, keeping his boat aimed directly north. The island dock is due north of the mainland dock. He rows his boat at a speed of 4 km/h relative to the water.



Where will he land?

(A) at the dock directly opposite his starting point

(B) 3 km downcurrent from the island dock

(C) 4 km downcurrent from the island dock

(D) 5 km downcurrent from the island dock

(E) 7 km downcurrent from the island dock

6

S17A
I.2.a
S17C
I.4.c

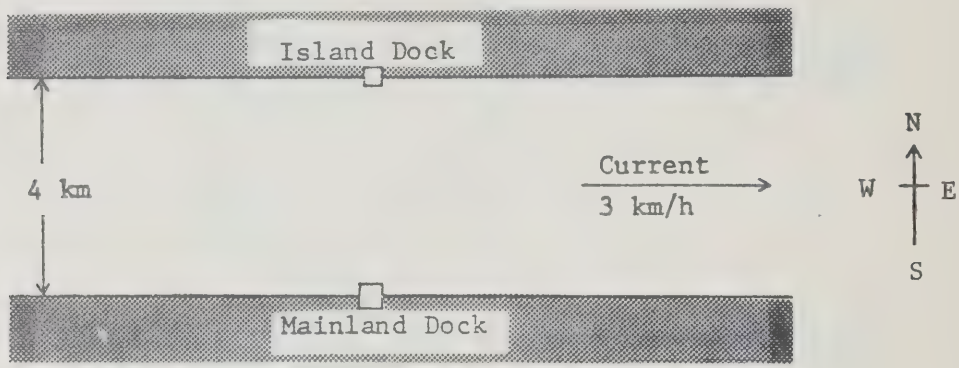
24

F1
A3

(D)

***
**

A man lives on an island 4 km offshore, across a channel which has a 3 km/h current when the tide is running. On a dark night, with the tide running, he rows from the mainland dock toward the island, keeping his boat aimed directly north. He rows his boat at a speed of 4 km/h relative to the water.



Because of the current he will have a speed relative to the earth of

(A) 1 km/h

(B) 3 km/h

(C) 4 km/h

(D) 5 km/h

(E) 7 km/h

7

S17C
I.4.c

24

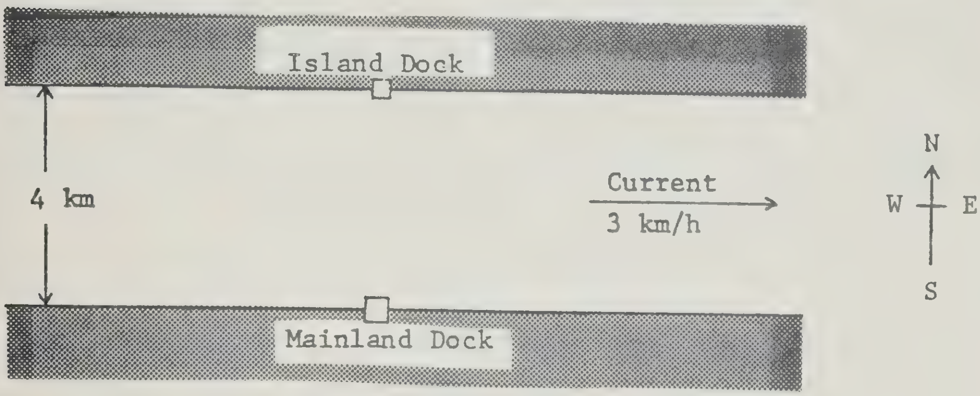
F1
A3

(D)

-

***

A man lives on an island 4 km offshore, across a channel which has a 3 km/h current when the tide is running. On a dark night, with the tide running, he rows from the mainland dock towards the island, keeping his boat aimed directly north. He rows his boat at a speed of 4 km/h relative to the water.



In order to row directly across to the island dock, he should have set his course upcurrent at an angle west of north. The sine of that angle is

(A) $\frac{5}{3}$

(B) $\frac{5}{4}$

(C) $\frac{4}{5}$

(D) $\frac{3}{4}$

(E) $\frac{3}{5}$

8 A student rolls a marble across a table. At the instant that the marble leaves the edge, the student
S17C drops a second marble from the edge of the table.
I.4.d Consider the following statements regarding the subsequent motions of the two marbles:

S 24
S 29 I. The marbles will have equal accelerations.
II. Both marbles will strike the floor at the
A8 same time.
III. Both marbles will have equal velocities as
(D) they strike the floor.

\- Which of the above statements will correctly describe the subsequent motions? (Neglect air
*** resistance.)

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) I, II, and III

9 A plane travelling at 200 m/s north turns and then travels south at 200 m/s. Its change of
S17C velocity is
I.4.c

(A) 0 m/s

25

(B) 200 m/s north

A3

(C) 200 m/s south

(E)

(D) 400 m/s north

*** (E) 400 m/s south
***

10

S17C
I.4.c

25

A3

(E)

***
***

As a vehicle goes from 3.0 m/s [N 90^{0} E] to 4.0 m/s [N 270^{0} E], the change in velocity is

(A) 1.0 m/s, [N 90^{0} E]

(B) 1.0 m/s, [N 270^{0} E]

(C) 5.0 m/s, [N 315^{0} E]

(D) 7.0 m/s, [N 90^{0} E]

(E) 7.0 m/s, [N 270^{0} E]

11

S17C
I.4.b

25

A7

(A)

-

***

Given the vectors $\vec{P}$ and $\vec{Q}$ above, which one of the vectors shown below best represents the vector $2\vec{P} - \vec{Q}$?

(A) 

(B) 

(C) 

(D) 

(E) 

12

S17C
I.4.f

25

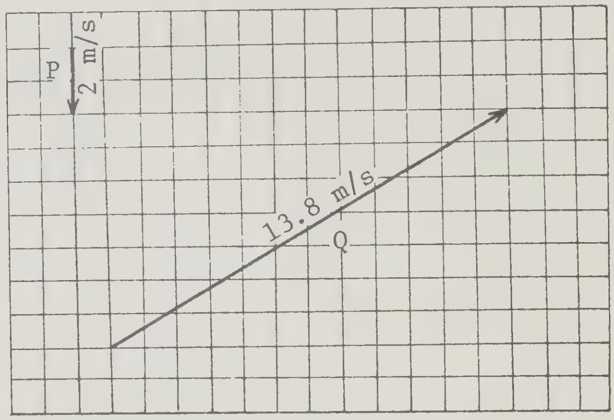
A7

(C)

-

***

Vectors P and Q in the grid below represent velocities. Each side of each little square in the grid represents a speed of 1 m/s.



Let vectors P and Q represent the initial and final velocities respectively of a particle over a 4.0 s time interval. Then the magnitude of the average acceleration during this interval is

(A) 3.25 m/s^2

(B) 3.45 m/s^2

(C) 3.75 m/s^2

(D) 13 m/s^2

(E) 15 m/s^2

13

S17C
I.4.b

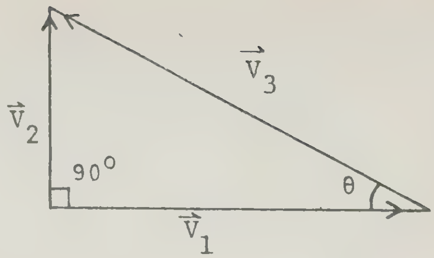
25

A7

(C)

***
**

The vector $\vec{V}_3$ in the diagram at the right is equivalent to



(A) $\vec{V}_1 - \vec{V}_2$

(B) $\vec{V}_1 + \vec{V}_2$

(C) $\vec{V}_2 - \vec{V}_1$

(D) $\vec{V}_1{}^2 + \vec{V}_2{}^2$

(E) $\vec{V}_1 \cos \theta$

14

S17C
I.4.f

25

F1
A11

(D)

\-

***

An airplane is flying north at 80 m/s. It makes a gradual turn maintaining a constant speed. 20 s later it completes the turn and is moving east at 80 m/s. The direction of its average acceleration, while making the turn, is best represented by

(A) 

(B) 

(C) 

(D) 

(E) 

15

S17A
I.2.a
S17C
I.4.c

S 25

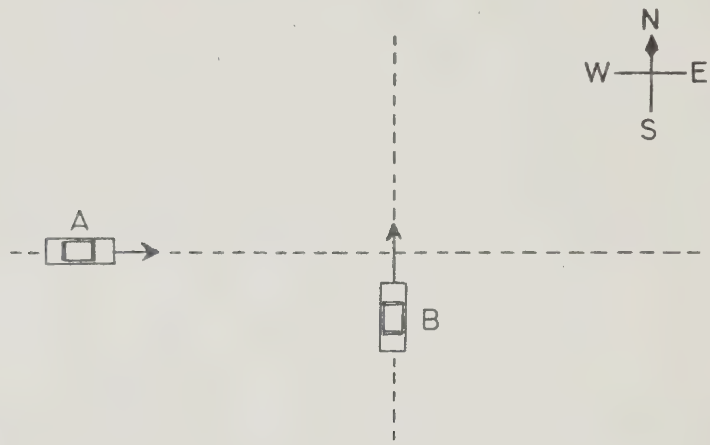
A7
F1

(B)

-

***

Two cars approach an intersection at right angles. Car A is travelling with a velocity of 30 km/h east, and car B is travelling with a velocity of 30 km/h north.



The velocity of B relative to A is

(A) 42 km/h SE

(B) 42 km/h NW

(C) 60 km/h NW

(D) 60 km/h SE

(E) 42 km/h NE

16

S17A
I.2.a
S17C
I.4.c

S 25

F1

(B)

-

**

A ship is travelling 8.0 m/s due west in still water. A passenger is walking along the deck at 3.0 m/s toward the back end of the ship. He throws an apple core north at 12 m/s. The velocity of the apple core relative to the water is

(A) $\sqrt{265}$ m/s in a direction between north and northwest

(B) 13 m/s in a direction between north and northwest

(C) 13 m/s in a direction between west and northwest

(D) 17 m/s in a direction between north and northwest

(E) $\sqrt{265}$ m/s in a direction between west and northwest

17

S17C
I.4.c

27

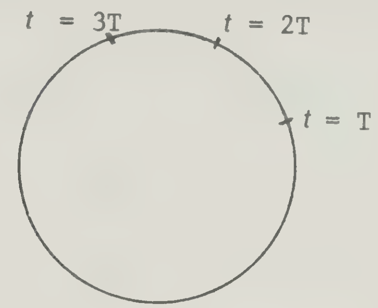
A11
A2

(B)

-

**

A proton situated in a magnetic field is observed to travel in a circular path. The positions of the proton at times T, 2T and 3T are shown in the figure below.



Which vector best represents the average velocity of the proton between t = T and t = 2T?

18

S17C
I.4.c

27

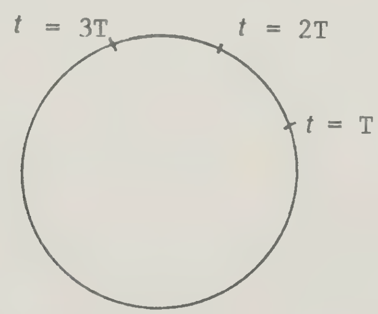
A2

(C)

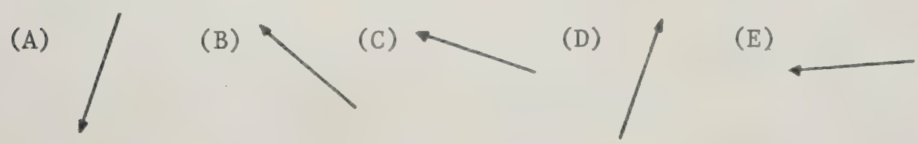
-

*

A proton situated in a magnetic field is observed to travel in a circular path. The positions of the proton at times T, 2T and 3T are shown in the figure below.



Which vector best represents the instantaneous velocity of the proton at t = 2T?



19

S17C
I.4.c

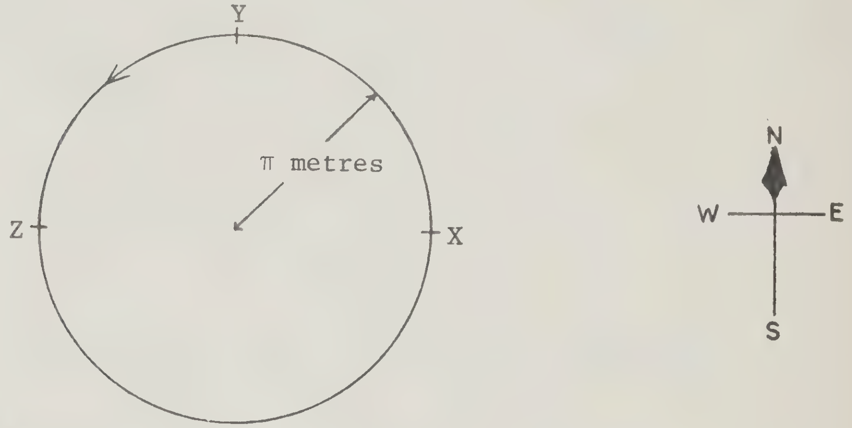
S27

F1

(B)

–
**

An object is moving in a circular path of radius π metres in a horizontal plane at a constant speed of 4.0 m/s.



The time required for one revolution is equal to

(A) $\frac{2}{\pi^2}$ s

(B) $\frac{\pi^2}{2}$ s

(C) $\frac{\pi}{2}$ s

(D) $\frac{\pi^2}{4}$ s

(E) $\frac{2}{\pi}$ s

20

S17C
I.4.b

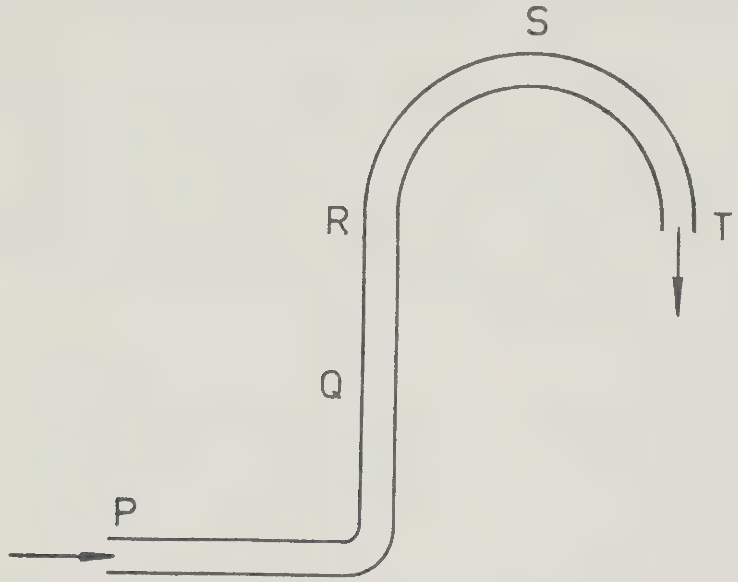
S 27
S 29

F1
A2
A8
A7

(E)

-
**

An air bubble is carried along a water pipe at constant speed by the water. The bubble enters the laboratory tap at P and moves in the direction indicated in the diagram below, leaving the tap at T.



In which section of the pipe is the overall change in the bubble's velocity greatest?

(A) PQ

(B) PS

(C) QS

(D) RS

(E) RT

21

S17C
I.3.c

S 27

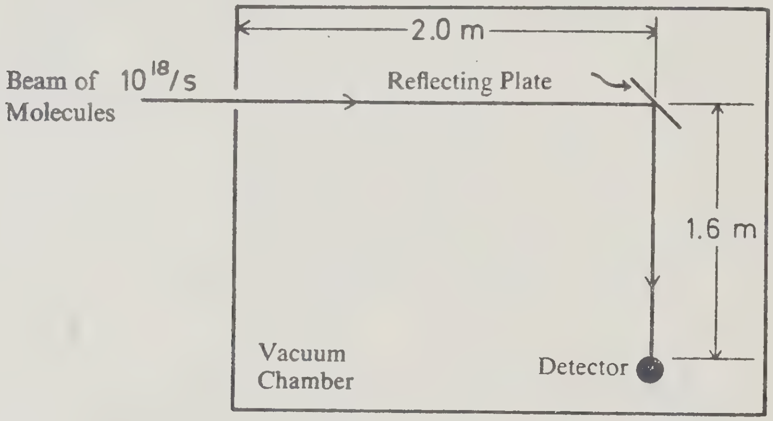
F1
A8

(C)

-

**

A beam containing 1.0×10^{18} molecules/s enters a vacuum chamber. After tracing out the path shown each molecule is absorbed by the detector. Each molecule has a mass of 5.0×10^{-26} kg and travels at a speed of 2.0×10^{3} m/s. (NOTE: The only function of the reflecting plate is to change the direction of the beam of molecules.)



The time required for a molecule after it enters the chamber to reach the detector is

(A) 8.0×10^{-4} s

(B) 1.0×10^{-3} s

(C) 1.8×10^{-3} s

(D) 5.6×10^{2} s

(E) 7.2×10^{3} s

22

S17C
I.4.c

S 27

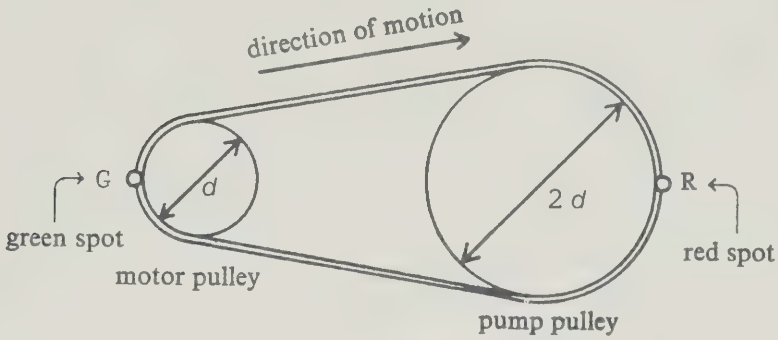
F1
A11

(C)

-

***

The diagram shows a motor driving a pump by means of a belt. The pump pulley diameter is twice the motor pulley diameter. There is a red spot (R) and a green spot (G) on the belt.



Which one of the following equations correctly relates the speed (v_G) of the green spot and the speed (v_R) of the red spot?

(A) $v_G = 4v_R$

(B) $v_G = 2v_R$

(C) $v_G = v_R$

(D) $v_G = \frac{v_R}{2}$

(E) $v_G = \frac{v_R}{4}$

23

S17C
I.4.c

S 27

A11
F1

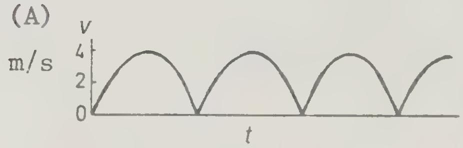
(A)

-

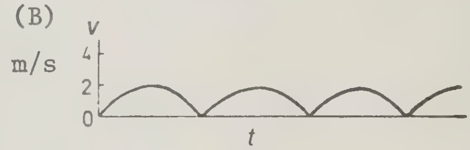
***

A car travels to the right with a speed of 2.0 m/s. Which of the following diagrams best represents the speed of a point on the rim of one of its wheels, of radius 0.5 m, with respect to the ground?

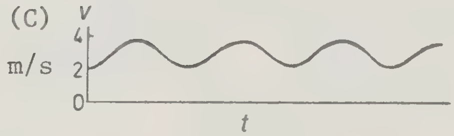
(A)



(B)

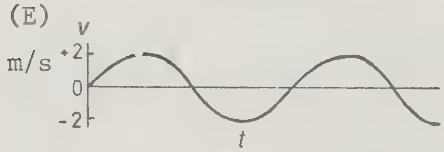


(C)



(D)

(E)



24

S17C
I.4.e

29

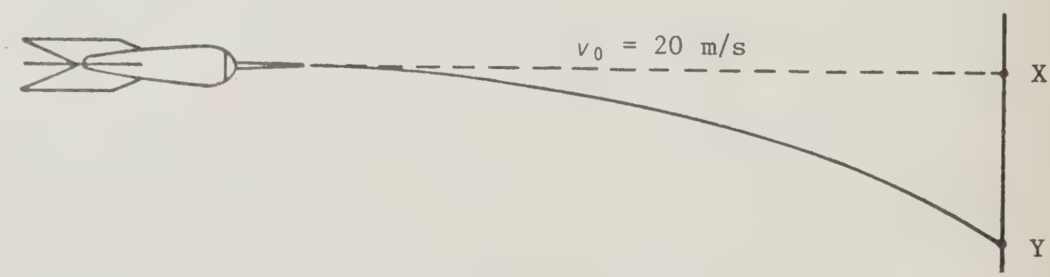
A8
F1

(E)

-

***

A dart is thrown horizontally toward X with a speed of 20 m/s. It hits a point Y 0.1 s later.



The distance XY will be approximately

(A) 2 m

(B) 1 m

(C) 0.5 m

(D) 0.1 m

(E) 0.05 m

25

S17C
I.4.a

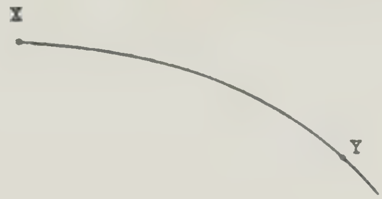
29

A3

(E)

*
*

A small projectile is launched horizontally in a vacuum and follows a path from X through Y as shown.



Choose the vector which best represents the displacement from X to Y.

26

S17C
I.4.e

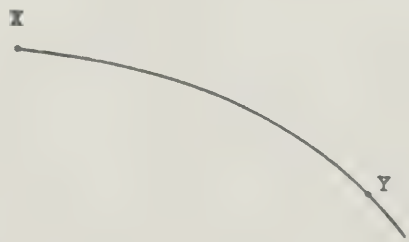
29

A3

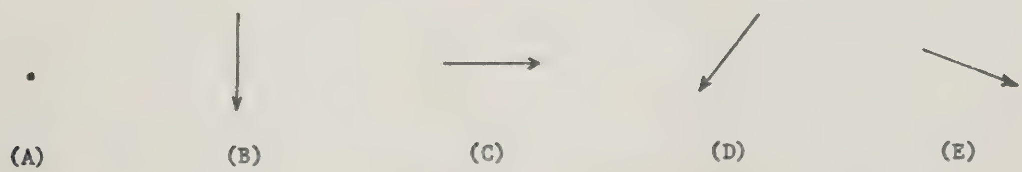
(C)

***
**

A small projectile is launched horizontally in a vacuum and follows a path from X through Y as shown.



Choose the vector which best represents the velocity at X.



27

S17C
I.4.f

29

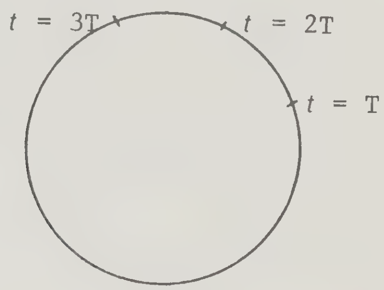
A2
A7

(A)

-

**

A proton situated in a magnetic field is observed to travel in a circular path. The positions of the proton at times T, 2T and 3T are shown in the figure below.



Which vector best represents the average acceleration of the proton between t = T and t = 3T?

28

S17C
I.4.e

29

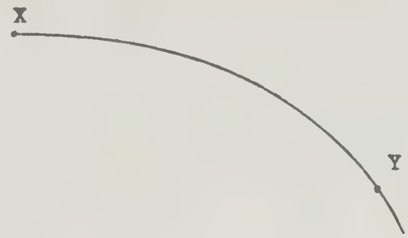
A3

(B)

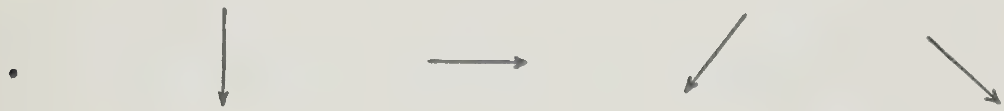
-

***

A small projectile is launched horizontally in a vacuum and follows a path from X through Y as shown.



Choose the vector which best represents the acceleration at Y.



(A) (B) (C) (D) (E)

29

S17C
I.4.e

29

F1
A8

(C)

***
***

An object is thrown horizontally with a velocity of 30 m/s from the top of a tower. It undergoes a constant downward acceleration of 10 m/s^2. The magnitude of its instantaneous velocity after 4 s, in metres per second, is

(A) 10

(B) 40

(C) 50

(D) 70

(E) 120

30

S17C
I.4.f

29

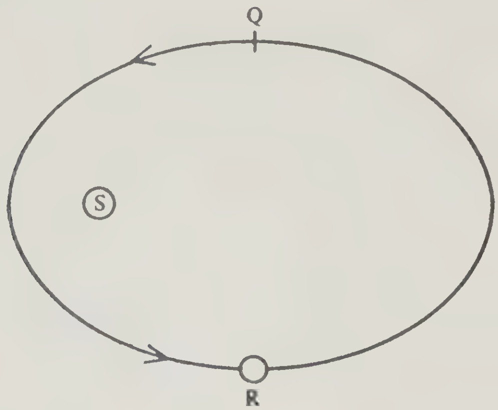
A8
A11

(E)

-

***

A planet moves in an elliptical orbit around a sun as shown below.



The direction of the planet's acceleration vector at R is

31

S17C
I.4.e

29

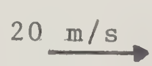
F1
A11

(E)

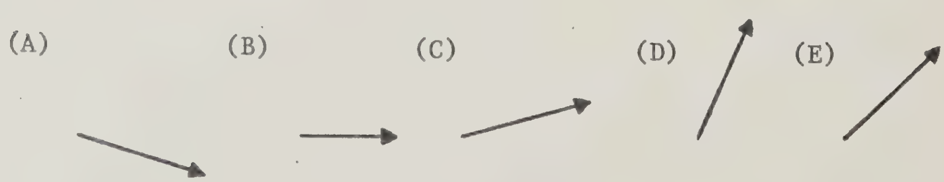
-

***

A ball is thrown a long distance across a field. Its flight along the curved path through the air lasts at least six seconds. Its velocity vector at a particular instant is horizontal as shown:



Neglect air resistance. Two seconds <u>before</u> this instant, its velocity vector was most like



32 A particle moves along the curve shown below, moving from P to S. As it moves its speed is constantly increasing. The arrows shown are velocity vectors.

S17C
I.4.f

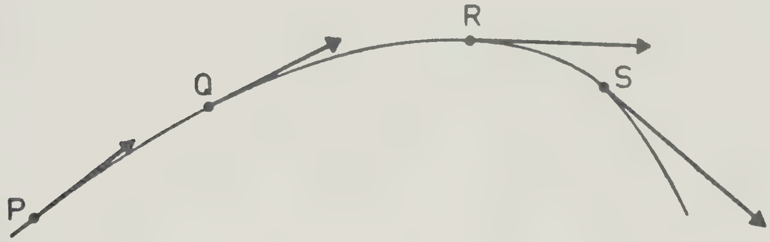
29

A7
A11

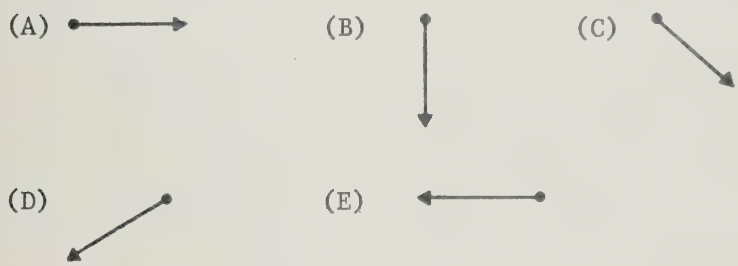
(C)

-

***



The best representation of the acceleration of the particle at R is indicated by



33 A projectile is fired from ground level such that it has an initial vertical speed of 20 m/s and initial horizontal speed of 30 m/s. How far from the point of firing does the projectile land? Take $g = 10\ m/s^2$, assume that the terrain is flat, and neglect air resistance.

S17C
I.4.e

S 29

F1
A8

(D)

-

***

(A) 40 m

(B) 60 m

(C) 80 m

(D) 120 m

(E) 180 m

34 If a particle moves at constant speed in a circular path, then the instantaneous velocity vector and the instantaneous acceleration vector are

S17C
I.4.f

30

A3

(C)

-

**

(A) both tangent to the circular path

(B) both perpendicular to the circular path

(C) perpendicular to each other

(D) opposite in direction

(E) none of the above

35 An airplane is flying north at 200 m/s. It makes a gradual turn maintaining a constant speed. 20.0 s later it completes the turn and is moving east at 200 m/s. The magnitude of its average acceleration while making its turn, in metres per second squared, is

S17C
I.4.f

30

F1

(C)

-

***

(A) 400

(B) 200

(C) 14.1

(D) 10.0

(E) 0

36 A ferris wheel at a carnival has a diameter of 10 m. It rotates at a rate of one revolution every minute. The magnitude of the centripetal acceleration on a student sitting in one of the ferris wheel chairs is

S17C
I.4.f

30
38

F1

(B)

-

***

(A) 0 m/s^2

(B) 0.05 m/s^2

(C) 0.1 m/s^2

(D) 7 m/s^2

(E) 385 m/s^2

37

S17C
I.4.f

30

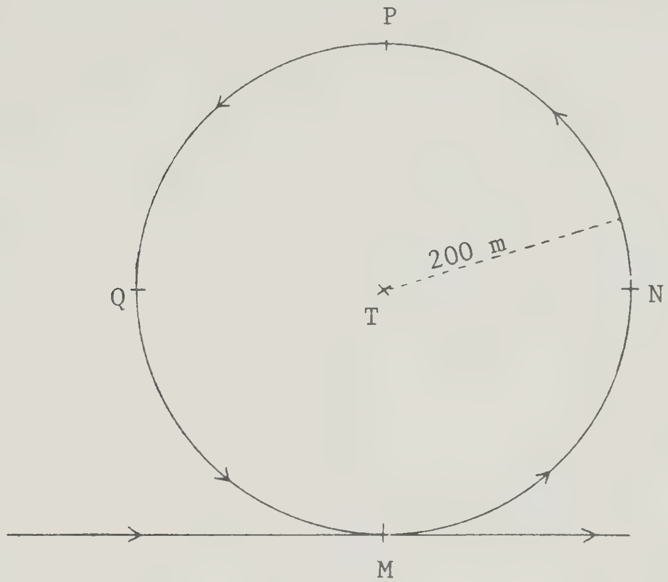
F1
A2

(A)

-

***

An airplane flies in a vertical circular loop of radius 200 m as shown in the diagram below.



Its instantaneous speed at M, starting the loop, is 80 m/s; at N, 40 m/s; at P, 50 m/s; at Q, 60 m/s, and at M, completing the loop, 80 m/s. If it travels from Q to M in 4.0 s, its average acceleration from Q to M is most accurately stated as

(A) 25 m/s^2 in a direction which slants upward to the right from the horizontal

(B) 25 m/s^2 in the direction of the line drawn from Q to M

(C) 100 m/s^2 in the direction of the line drawn from Q to T

(D) 25 m/s^2 in a direction which is constantly tangential to the circle

(E) 100 m/s^2 in a direction which slants upward to the right from the horizontal

38 An object is moving in a circular path of radius π metres in a horizontal plane at a constant speed of 4.0 m/s.

S17C
I.4.f

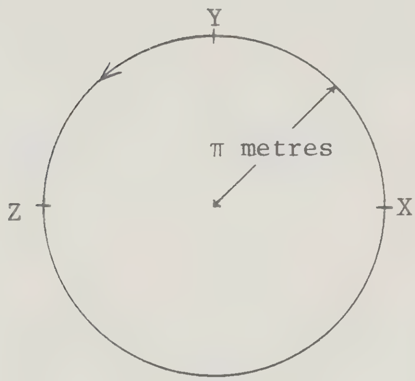
30

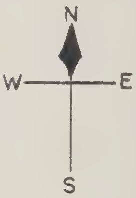
F1
A1

(D)

–

**





While the object is passing through the point X the direction of its instantaneous acceleration is

(A) north

(B) northwest

(C) south

(D) west

(E) east

39 An air bubble is carried along a water pipe at constant speed by the water. The bubble enters the laboratory tap at P and moves in the direction indicated in the diagram below, leaving the tap at T.

S17C
I.4.f

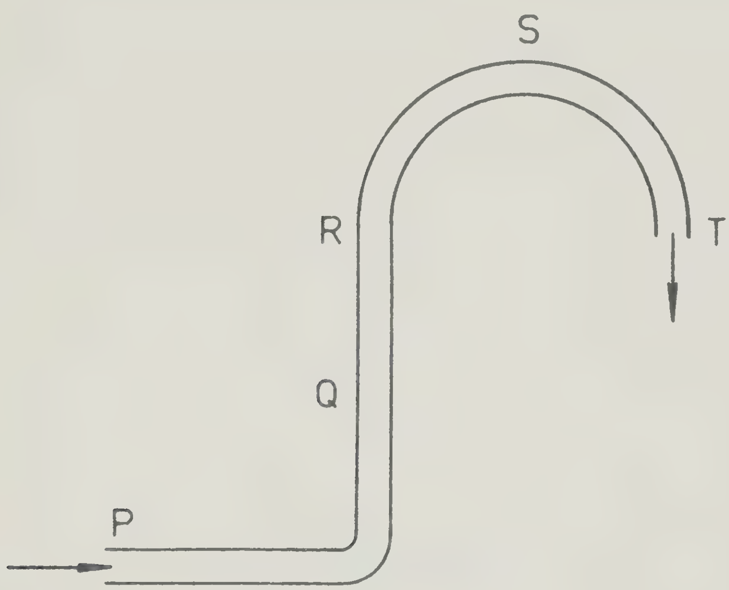
S 30

F1
A2
A8
A7

(A)

-

***



In which section does the bubble undergo its greatest instantaneous acceleration?

(A) PQ

(B) QR

(C) QS

(D) RS

(E) RT

40

S17C
I.4.f

S 30

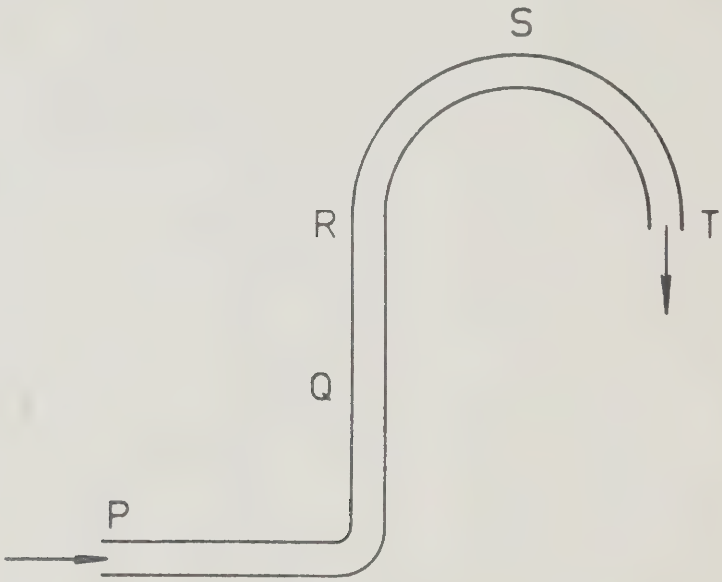
F1
A2
A8
A7

(B)

-

***

An air bubble is carried along a water pipe at constant speed by the water. The bubble enters the laboratory tap at P and moves in the direction indicated in the figure below, leaving the tap at T.



In which section is the magnitude of the average acceleration of the bubble least?

(A) PQ

(B) PS

(C) QS

(D) RS

(E) RT

41

S17C
I.4.f

S 30

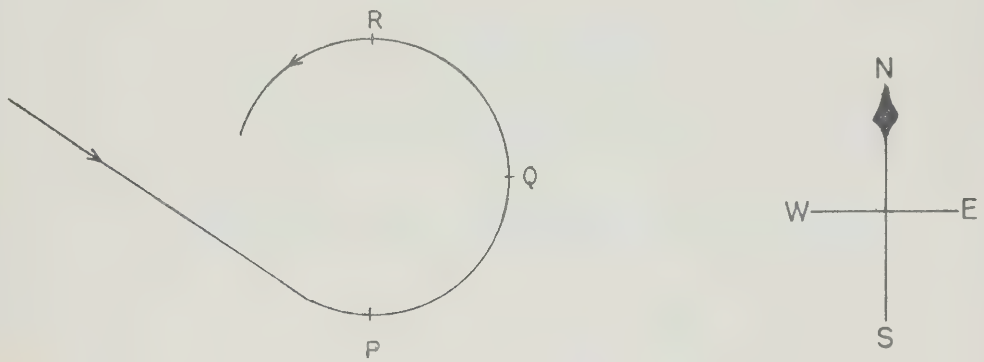
F1
A1

(B)

-

***

A figure-skater follows the path of the curve shown below. The arc is circular in shape with P, Q and R due south, east, and north of the circle's center. While the skater coasts along the path shown, her speed decreases uniformly because of friction.



Her acceleration is due west

(A) at point P

(B) at some point between P and Q

(C) at point Q

(D) at some point between Q and R

(E) at point R

42

S17C
I.4.f

S 30

A8
F1

(A)

-

***

A car travels to the right with a speed of 2.0 m/s. Each tire has a radius of 0.5 m. The acceleration of a point on the tire in contact with the ground is

(A) 8 m/s^2 upward

(B) 8 m/s^2 to the right

(C) 0

(D) 4 m/s^2 upward

(E) 4 m/s^2 downward

43 The following information relates to the motion of three objects P, Q and R.

S17C
I.4.f

S 30

A1
A8

(C)

-

***

I. Object P moves in a straight line with increasing speed.

II. Object Q moves in a circle with constant speed.

III. Object R moves along a curved path with increasing speed.

In which of the three cases has the object an acceleration <u>component</u> in the direction of motion?

(A) I only

(B) I and II only

(C) I and III only

(D) II and III only

(E) III only

D Y N A M I C S

FORCE AND NEWTON'S LAWS

1 A force is applied, as shown, to a 20 kg object in contact with a frictionless wall.

S17C
III.1.d The minimum force, $\vec{F}$, in newtons, required to prevent the object from sliding down the wall is

31

F1

(E)

–

***

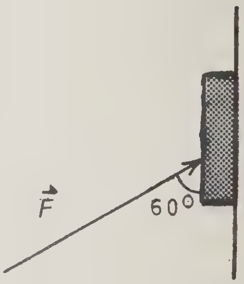
(A) 10

(B) 20

(C) 100

(D) 200

(E) 400



2 A student was working on a satellite problem and had simplified the solution as far as 57.3 $N \cdot s^2/m$.

S17A
I.2.c
S17C
III.1.d The student was solving for

31

A7
A2

(B)

–

***

(A) force

(B) mass

(C) acceleration

(D) period

(E) radius

3

S17A
I.2.c
S17C
III.1.d

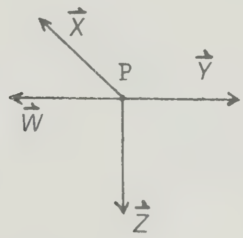
31

F1
A3

(A)

***
**

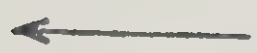
Vectors $\vec{W}$, $\vec{X}$, $\vec{Y}$ and $\vec{Z}$ represent forces of equal magnitude acting on a point P as shown.



Which of the following vectors best represents the resultant (net) force acting on P?

(A) 

(B) 

(C) 

(D) 

(E) 

4

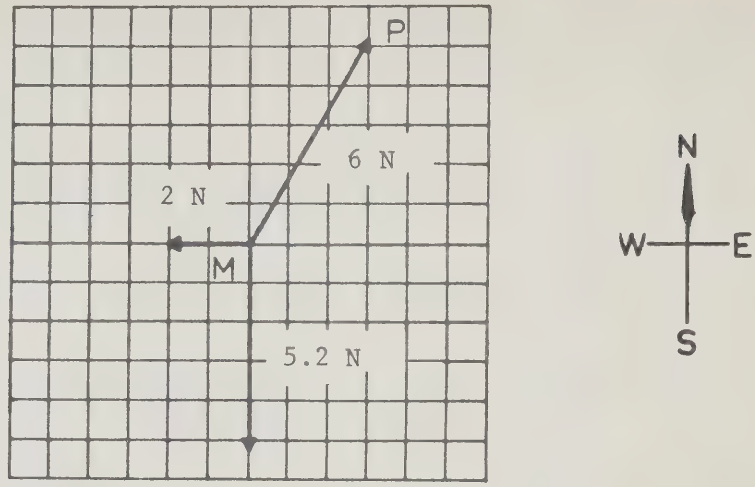
S17A
I.2.c
S17C
III.1.d

32
25

A7
B3

(A)

***



If an object is subjected to the combination of forces shown in the above diagram, which one of the following forces also would have to be applied in order for the object to move with uniform velocity?

(A) 1 N west

(B) 1 N east

(C) 1.2 N in the direction MP

(D) 13.2 N in a direction toward point M

(E) No additional force is required to produce uniform velocity.

5

S17A
I.2.b
S17C
III.1.a

32

A3

(D)

*

An object moving at a constant velocity must

(A) have a net force acting on it

(B) eventually stop due to the force of gravity

(C) not have any force of gravity acting on it

(D) have all forces that act on it balancing each other

(E) have no force of friction acting on it

6 The upward forces acting on an elevator total 5.0 kN. The only other force acting on the elevator is the downward force of gravity of 5.0 kN. The elevator could be moving

S17A
I.2.b
S17C
III.1.b

32

A3
A8
F1

(E)

*
*

(A) upward with increasing speed

(B) upward with decreasing speed

(C) downward with increasing speed

(D) downward with decreasing speed

(E) upward with constant speed

7 An airplane moves in straight level flight at constant velocity. What is the <u>net</u> force acting on it if the mass of the plane is 1000 kg and the frictional drag of the air is 1800 N?

S17A
I.2.b
S17C
III.1.a

32

F1
A8

(D)

***
***

(A) 11 800 N

(B) 10 000 N

(C) 1800 N

(D) 0

(E) insufficient information is given to determine the net force

8

S17C
III.1.a

32
S29

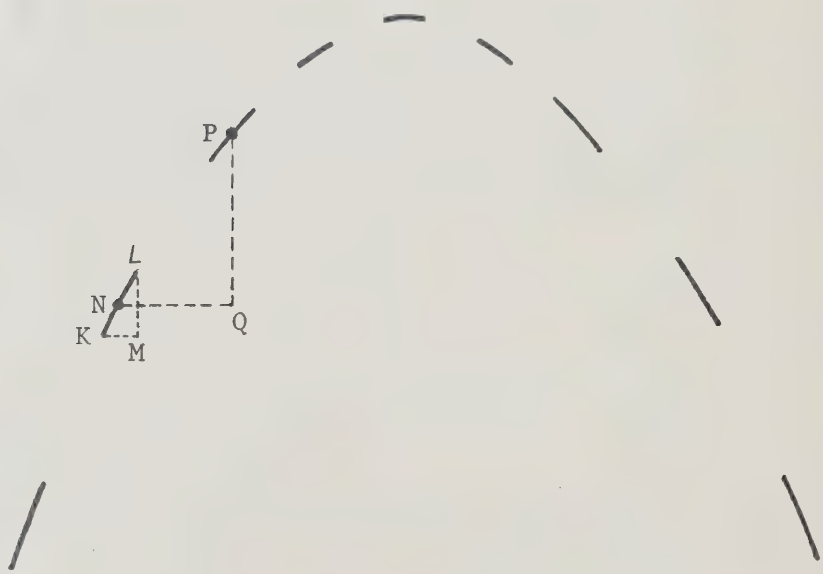
A8
A11

(C)

-
***

The figure below represents a multiple-flash photograph taken by an experimenter while studying the motion of a steel ball projected into the air. The ball was photographed through a narrow slit near the edge of a disc spinning at constant speed. The black streaks indicate the path of the ball during the intervals when the slit is in front of the open camera shutter. Sets of measurements which can be made on such a photo include:

the length of each streak, such as KL
the horizontal extent of each streak, such as KM
the vertical extent of each streak, such as LM
the horizontal distance between the centres of successive streaks, such as NQ
the vertical distance between the centres of successive streaks, such as QP



If air resistance were eliminated, in which of the following sets would all the measurements be the same?

(A) Only the horizontal extent of each streak.

(B) Only the horizontal distance between the centres of successive streaks.

(C) Both the horizontal extent of each streak and the horizontal distance between the centres of successive streaks.

(D) Some other of the listed sets or combination of sets of measurements.

(E) None of the sets listed.

9

S17A
I.2.b
S17C
III.1.a

32

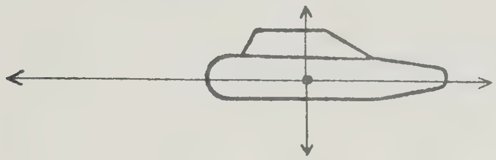
F1
A3
A8

(D)

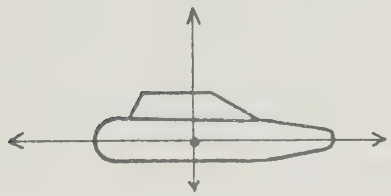
**
***

A submarine is travelling underwater at a constant velocity. Which diagram best represents the forces acting on the submarine?

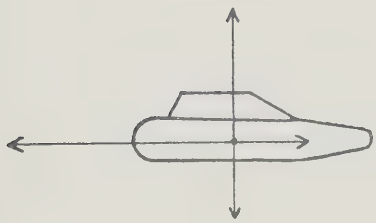
(A)



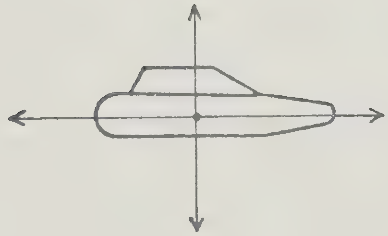
(B)



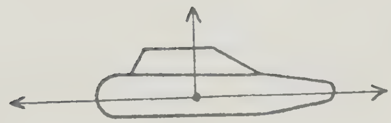
(C)



(D)



(E)



10

S17A
I.2.a
S17C
III.1.d

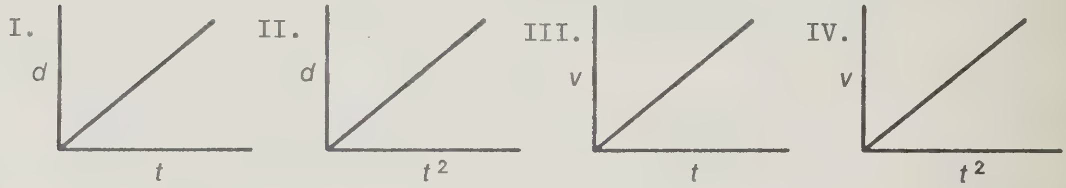
33

A11
A7
A8

(D)

-
***

A constant force is used to accelerate an object from rest along a smooth horizontal surface. Which single graph, or pair of graphs, shown below correctly describes the resulting motion of the object?
(d = distance, t = time, v = speed)



(A) I only

(B) II only

(C) III only

(D) II and III only

(E) I and IV only

11

S17A
I.2.c
S17C
III.1.b

33

A3

(D)

**
**

If an object is moving in a straight line due west with its speed changing, the net force acting on the object

(A) must be zero

(B) must be west

(C) must be east

(D) must be east or west

(E) could be east, west or zero

12

S17C
III.2.b

33

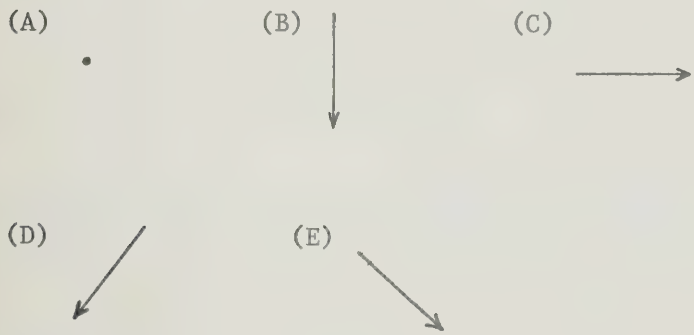
A3

(B)

***
***

A small projectile is launched horizontally in a vacuum and follows a path from X through Y as shown.

Choose the vector which best represents the net force acting on the particle at Y.



13

S17A
I.2.c
S17C
III.1.b

33

A8

(C)

**
-

A forward moving car is coasting to a stop on a straight, level road. The net external force on the car must be

(A) zero

(B) forward

(C) backward

(D) downward

(E) upward

14

S17C
III.2.c

33

A10

(E)

***
**

A satellite is in a circular orbit above the earth's atmosphere. In the absence of friction, which of the following statements is true?

(A) Its acceleration and velocity are in the same direction.

(B) There is no force acting on it.

(C) Its velocity is constant.

(D) It must fall back to earth when its fuel is exhausted.

(E) It is accelerating towards the earth.

15

S17A
I.2.c
S17C
III.1.b

33

D3
F1

(A)

***

An object travelling in a straight line toward a point P is found to be 40 m, 32 m, 22 m and 10 m from point P at the ends of 4 successive seconds. The net force exerted on the object is

(A) constant and acts in the direction of the motion

(B) increasing and acts in the direction of the motion

(C) constant and acts in the direction opposite to the motion

(D) increasing and acts in the direction opposite to the motion

(E) decreasing and acts in the direction opposite to the motion

16

S17C
III.2.a

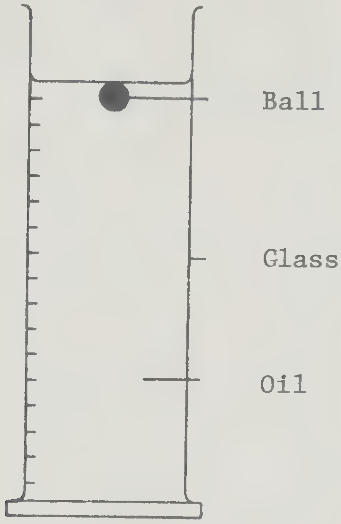
S 33

F1
A11

(A)

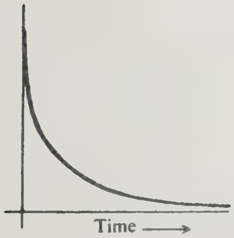
-
***

A ball falls from rest in oil. It experiences a retarding force which is directly proportional to its velocity.

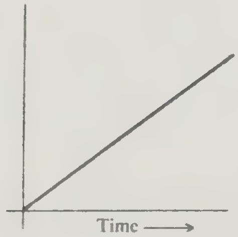


Which graph best represents the acceleration of the ball as a function of its time of fall from rest?

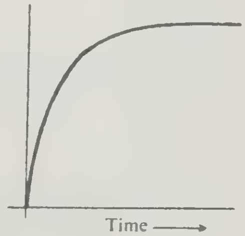
(A)



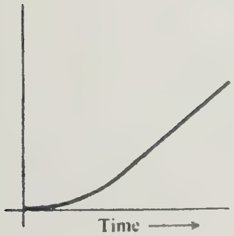
(B)



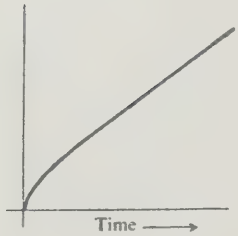
(C)



(D)



(E)



17 A ball falls from rest in oil. It experiences a retarding force which is directly proportional to its velocity.

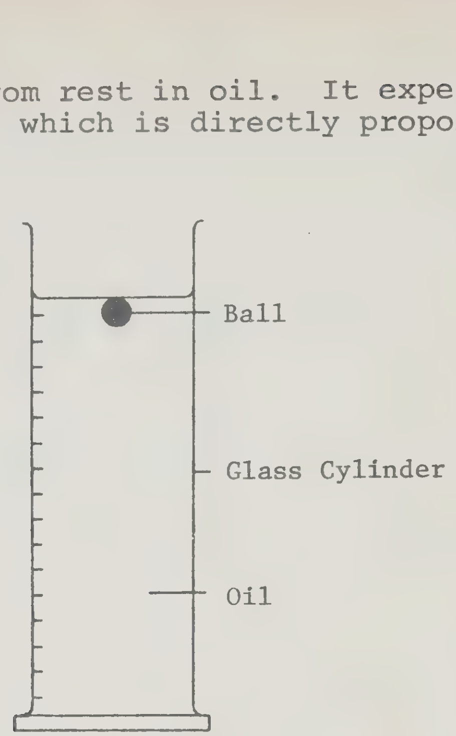
S17C
III.2.a

S33
16

F1
All

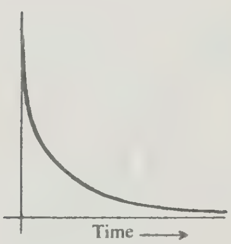
(C)

-
***

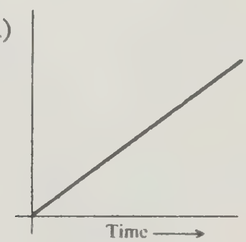


Which graph best represents the velocity of the ball as a function of its time of fall from rest?

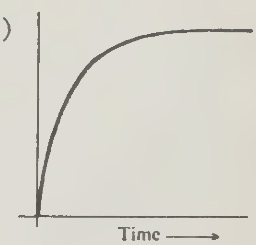
(A)



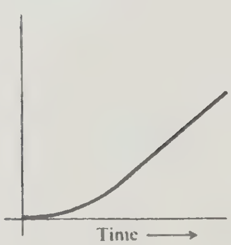
(B)



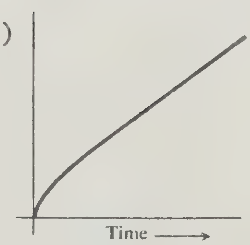
(C)



(D)



(E)



18

S17A
I.2.c
S17C
III.1.b

33
17

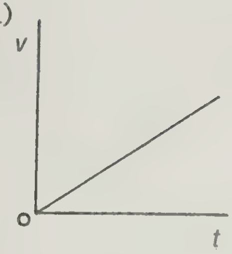
A11

(A)

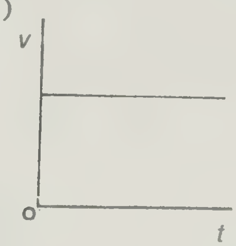
***
***

A cart, initially at rest, is pulled with a constant, unbalanced force. Which speed-time graph best represents the motion of the cart?

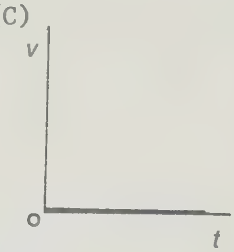
(A)



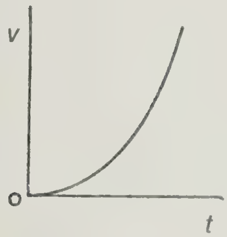
(B)



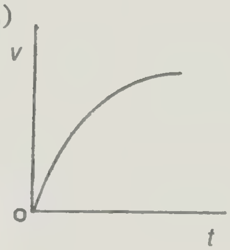
(C)



(D)



(E)



19

S17C
III.1.b

33

F1

(A)

**
**

A man suspends a red herring on a newton spring scale in an elevator. The scale shows the highest reading when the elevator

(A) moves upwards with increasing speed

(B) moves upwards with decreasing speed

(C) remains stationary

(D) moves downwards with increasing speed

(E) moves downwards at constant speed

20 An ideal spring rests on a horizontal, frictionless surface with one end fixed (Fig. I). An object, m is pressed against the free end of the spring causing it to compress through a distance *d* (Fig. II). The object is then released and is observed as it moves through a distance 2*d*.

S17C
III.6.a

S 33

A11
F1
A8

(E)

\-
***

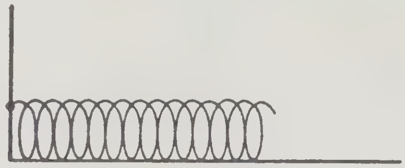


Fig. I

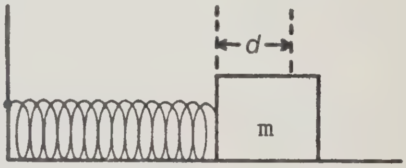
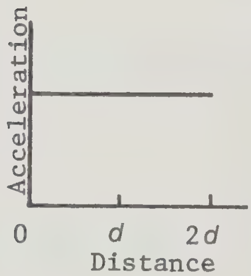


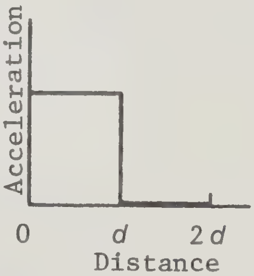
Fig. II

The acceleration versus distance graph for the object is best represented by

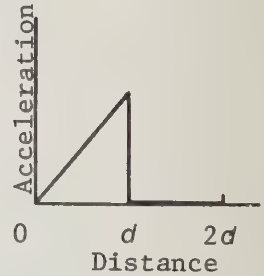
(A)



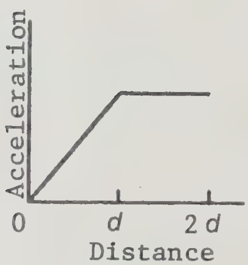
(B)



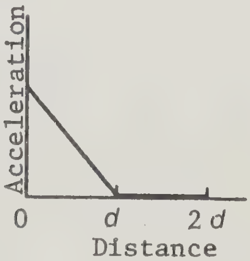
(C)



(D)



(E)



21

S17C
III.1.d

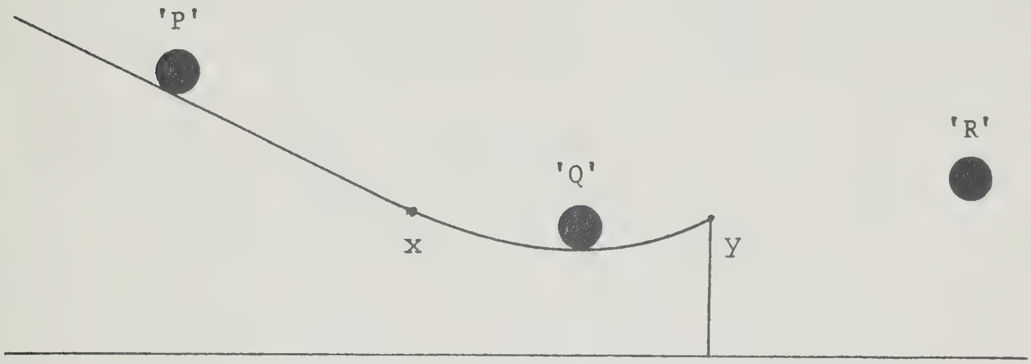
33

F1

(C)

***
**

A steel ball is placed at the top of the ramp shown and released. The ramp is curved from x to y. (Consider the ramp to be frictionless.)



The acceleration of the ball at position 'R' is best represented by the vector

(A) 

(B) 

(C) 

(D) 

(E) zero

22

S17A
I.2.c
S17C
III.1.a

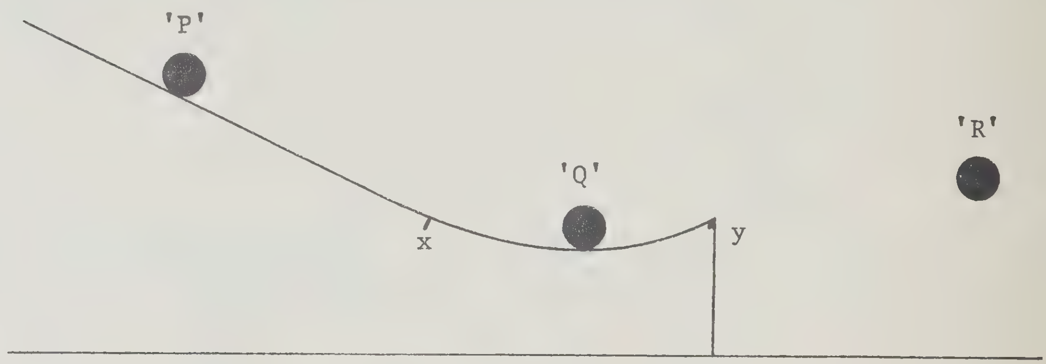
33

F1

(A)

**
**

A steel ball is placed at the top of the ramp shown and released. The ramp is curved from x to y. (Consider the ramp to be frictionless.)



The acceleration of the ball at position 'P' is best represented by the vector

(A) 

(B) 

(C) 

(D) 

(E) zero

23

S17A
I.2.c
S17C
III.1.b

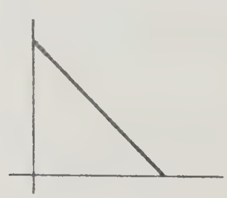
S 34

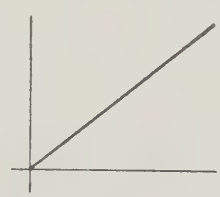
A11

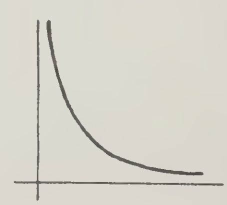
(D)

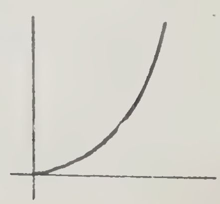
\-
***

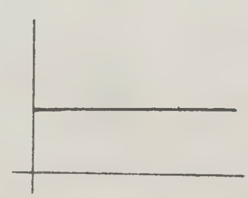
A cart is placed on a frictionless, horizontal surface and is moved by means of elastic bands of identical structure. The mass of the cart may be changed by placing masses on it. From the graphs below, select the one which best describes distance versus time when the cart is pulled by a constant force.

(A) 

(B) 

(C) 

(D) 

(E) 

24 A tape from a laboratory experiment has the appearance shown below. The dots were made by a vibrator with a steady frequency of 20 Hz.

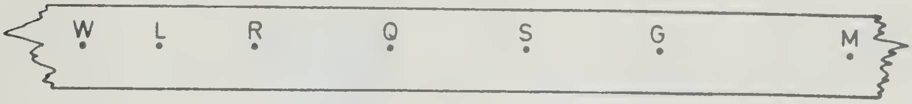
S17A
I.2.c
S17C
III.1.b

S 34

D3

(C)

\-
***



Choose the correct statement

(A) The speed at point Q must be equal to the average speed between W and M.

(B) The tape could have been made by a freely falling object.

(C) The tape indicates non-uniform acceleration.

(D) The tape could have been made by a constant unbalanced force acting on a given mass.

(E) The tape could not have been made by a decelerating object.

25 A cart is placed on a frictionless, horizontal surface and is moved by means of elastic bands of identical structure. The mass of the cart may be changed by placing masses on it. From the graphs below, select the one which best describes acceleration versus the number of identically stretched bands pulling the cart.

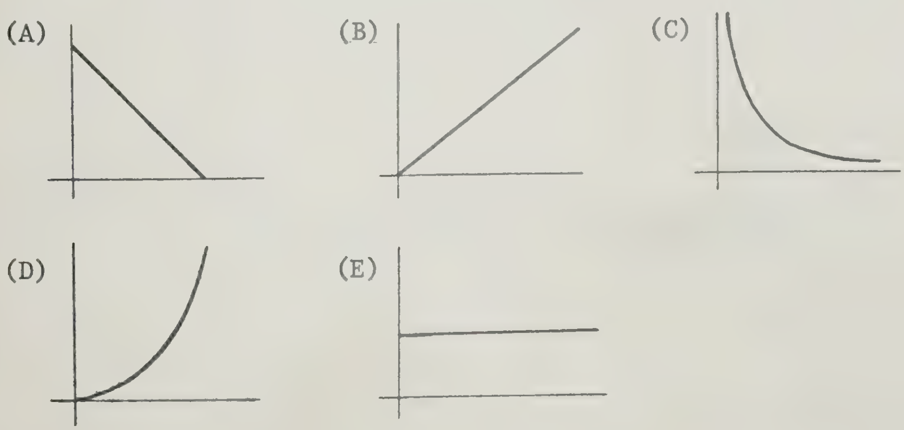
S17A
I.2.c
S17C
III.1.d

34

D3
A11

(B)

\-
**



26

S17A
I.2.c
S17C
III.1.d

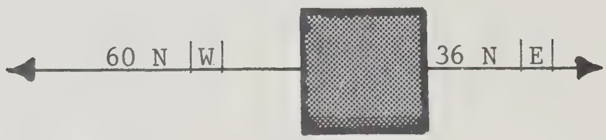
35

A8

(B)

**
*

Suppose that the only forces acting on a 12 kg mass are those shown in the diagram.



The acceleration of the mass shown is

(A) 0.5 m/s^2 [W]

(B) 2.0 m/s^2 [W]

(C) 5.0 m/s^2 [W]

(D) 8.0 m/s^2 [W]

(E) 24 m/s^2 [W]

27

S17A
I.2.c
S17C
III.1.b

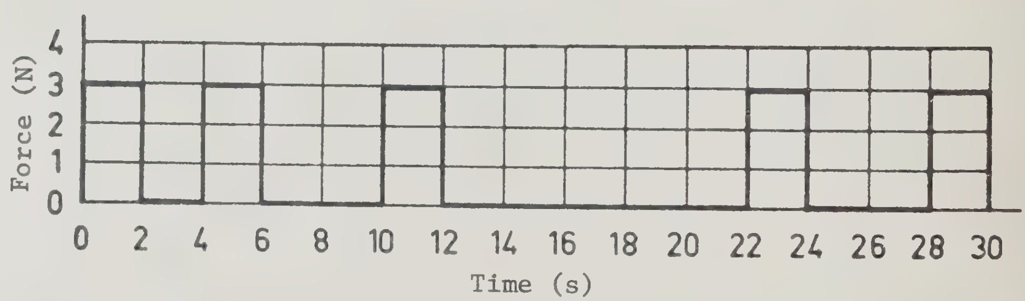
35

A8
A11
F1

(C)

–
***

An intermittent force of the type shown in the diagram below is applied to an object.



What constant force acting over the same time interval would produce the same velocity change?

(A) $\frac{1}{3}$ N

(B) $\frac{1}{2}$ N

(C) 1 N

(D) $\frac{3}{2}$ N

(E) 3 N

28

S17A
I.2.c
S17C
III.1.d

35

A8

(E)

***
**

A net force of magnitude F causes a mass m_1 to undergo an acceleration of magnitude a_1; the same force causes a mass m_2 to undergo an acceleration of magnitude a_2.

If $a_1/a_2 = 4$, then $m_1/m_2 =$

(A) 8

(B) 4

(C) 2

(D) $\frac{1}{2}$

(E) $\frac{1}{4}$

29

S17C
III.1.d

35

A8
F1

(B)

\-
***

A force F acts horizontally on a mass M which is at rest on a horizontal, frictionless surface. After the force has acted through a distance of 1.0 m, the mass has acquired a velocity V. If a force $2F$ acted for the same distance on a mass $\frac{1}{2}M$ at rest on the same surface, the second mass would acquire a velocity of

(A) $4\ V$

(B) $2\ V$

(C) V

(D) $\frac{V}{2}$

(E) $\frac{V}{4}$

30

S17A
I.2.c
S17C
III.1.b

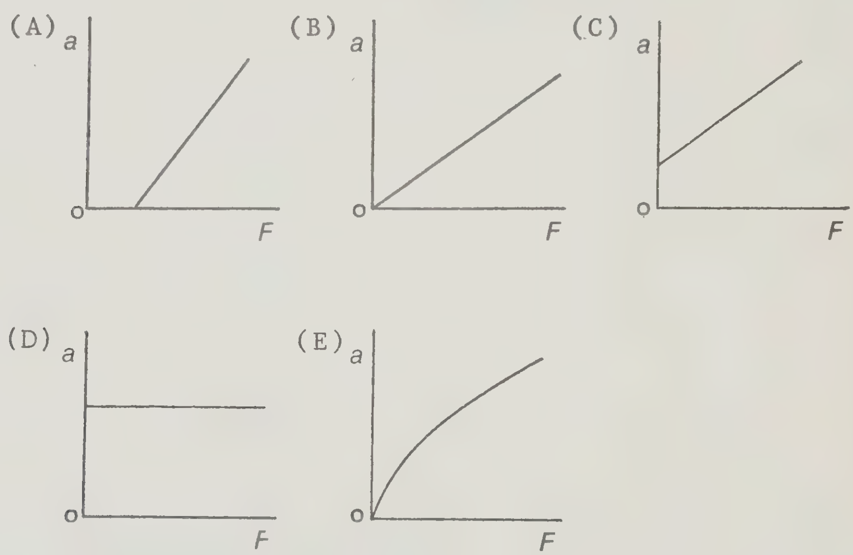
35

D3

(A)

***
***

Varying numbers of identical, equally stretched rubber bands are used to provide forces to pull a cart. In each trial the acceleration is constant. Taking frictional force into account (force on the graph is measured in number of elastic bands), which of the following acceleration versus force graphs is most nearly correct?



31

S17A
I.2.c
S17C
III.1.d

35

F1

(D)

**
**

A man applies a force of 220 N horizontally to the right against a 50 kg crate. The force of friction between the crate and floor is 200 N. If the crate is pushed 2.0 m, the magnitude of the acceleration of the crate, expressed in m/s^2, is

(A) 8.4

(B) 4.4

(C) 4.0

(D) 0.40

(E) zero

32 A steadily increasing force, acting in a fixed direction, is applied to a body of mass 4.0 kg

S17C which is initially at rest. Below is the graph

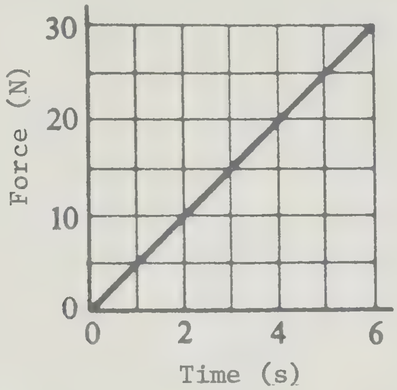
III.1.d of the force versus time.

35

F1
A7

(B)

\-
***



The speed of the object at the end of the first 4 s is

(A) 5 m/s

(B) 10 m/s

(C) 20 m/s

(D) 22.5 m/s

(E) 40 m/s

33 An 8.0 N force is exerted for 4.0 s on a 16 kg mass, causing it to move in a straight line. The change

S17C in speed of the mass will be

III.1.d

35
19

F1
A8

(B)

\-
**

(A) 0.5 m/s

(B) 2 m/s

(C) 4 m/s

(D) 8 m/s

(E) 32 m/s

34

S17A
I.2.c
S17C
III.1.b

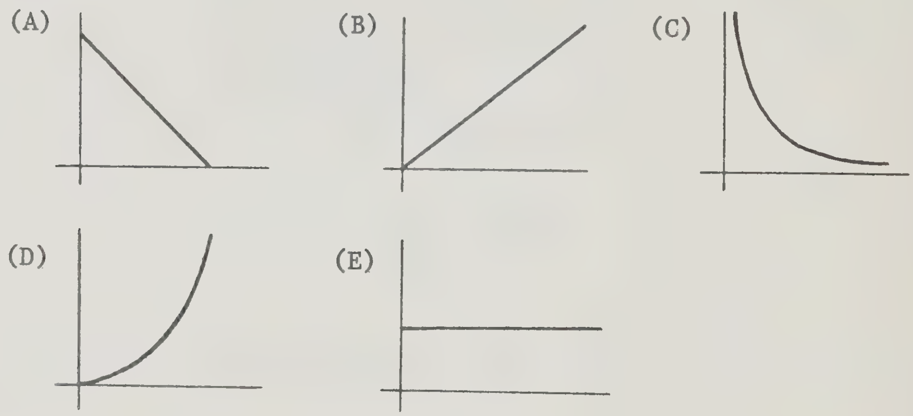
35

D3
All

(C)

***

A cart is placed on a frictionless, horizontal surface and is moved by means of elastic bands of identical structure. The mass of the cart may be changed by placing masses on it. From the graphs below, select the one which best describes acceleration versus the mass of the cart when pulled by a constant force.



35

S17A
I.2.c
S17C
III.1.d

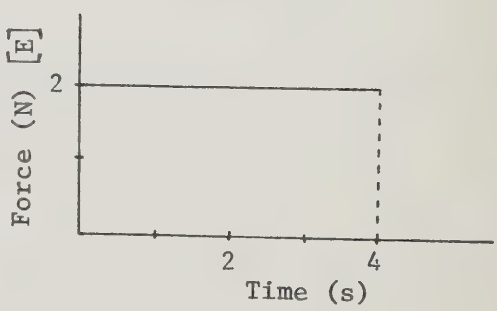
35

F1

(D)

***
**

An object of mass 2.0 kg, has an initial velocity of 5.0 m/s east, and is acted upon by the force shown in the following graph.



The object's final velocity will be

(A) 4 m/s [E]

(B) 5 m/s [E]

(C) 8 m/s [E]

(D) 9 m/s [E]

(E) 13 m/s [E]

36

S17C
III.1.d

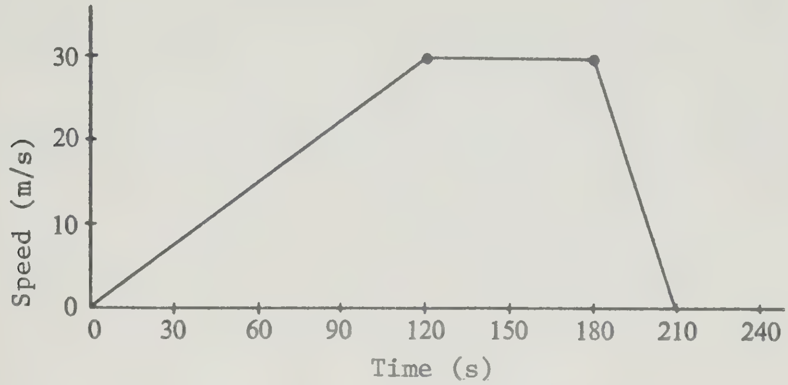
35

A8
A7
F1

(C)

-
**

The graph below shows the speed as a function of time for an automobile with a mass of 1.5 x 10^3 kg.



The constant braking force applied to stop the car was

(A) 50 N

(B) 3.8 x 10^2 N

(C) 1.5 x 10^3 N

(D) 4.5 x 10^4 N

(E) 1.5 x 10^5 N

37

S17C
III.1.d

35

F1

(C)

***
***

A string with a mass on each end hangs over a frictionless peg as shown. The acceleration of the system has a magnitude of

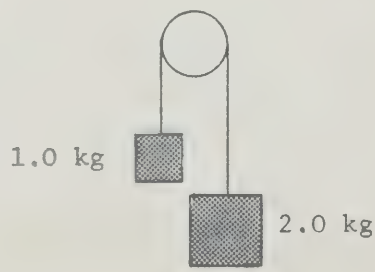
(A) 1.0 m/s^2

(B) 2.0 m/s^2

(C) 3.3 m/s^2

(D) 6.7 m/s^2

(E) 10 m/s^2



38 A 700 kg elevator suspended by a cable accelerates downwards at 3.0 m/s^2. The force exerted by the cable on the elevator is

S17A
I.2.c
S17C
III.1.d

35

F1
A8

(C)

***
***

(A) 2.1 kN upwards

(B) 2.1 kN downwards

(C) 4.9 kN upwards

(D) 9.1 kN downwards

(E) 9.1 kN upwards

39 A 6 kg object is moving south. A net force of 12 N north acting on it will provide an acceleration of

S17A
I.2.c
S17C
III.1.d

35

F1
A8

(A)

**
**

(A) 2 m/s^2 [N]

(B) 2 m/s^2 [S]

(C) 6 m/s^2 [N]

(D) 18 m/s^2 [N]

(E) 72 m/s^2 [S]

40 An 8.0 kg ball is given an initial velocity of 10 m/s and then is allowed to roll along a platform. An unbalanced force of 2.0 N opposes its motion. For what length of time will it roll before stopping?

S17A
I.2.c
S17C
III.1.d

35
21

F1

(E)

**
**

(A) 0.025 s

(B) 0.25 s

(C) 1.6 s

(D) 2.5 s

(E) 40 s

41

S17C
III.1.d
35
F1
A8
(E)
-
***

The speed of a kilogram mass increases uniformly from 20 m/s at point P to 40 m/s at point Q along a straight horizontal path PQR. From Q to R the mass slows down uniformly, coming to rest at R. The time taken by the mass in travelling from Q to R is ten times that taken from P to Q.

The ratio of the unbalanced force acting on the mass from P to Q to that acting from Q to R is

(A) 4:1

(B) 10:1

(C) -1:1

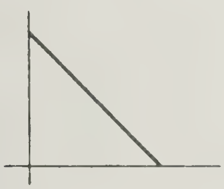
(D) -2:1

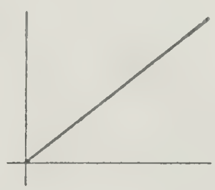
(E) -5:1

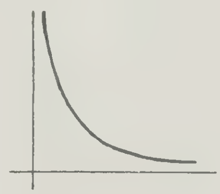
42

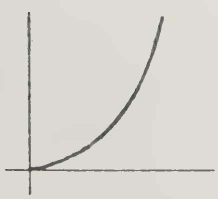
S17A
I.2.c
S17C
III.1.d
S 35
D3
A11
(D)
-
**

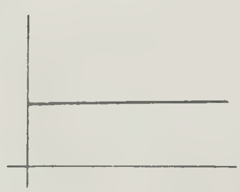
A cart is placed on a frictionless, horizontal surface and is moved by means of elastic bands of identical structure. The mass of the cart may be changed by placing masses on it. From the graphs below, select the one which best describes speed versus time when the cart is pulled by a force which is increasing uniformly with time.

(A)


(B)


(C)


(D)


(E)


43 A ball falls from rest in oil. It experiences a retarding force which is directly proportional to its velocity.

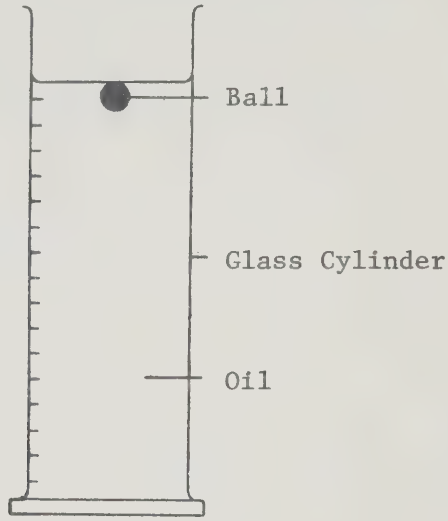
S17C
III.2.a

S 35

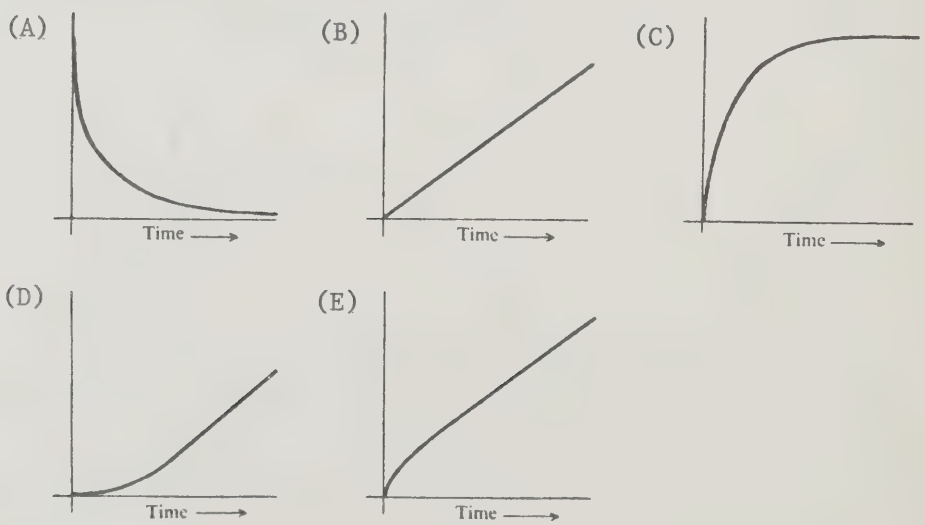
F1
A11

(D)

-
***



Which graph best represents the distance of the ball from its initial position as a function of time while the ball is falling from rest?



44

S17C
III.2.a

35

A8

(D)

-
***

An experimenter and some equipment are located on a platform at the surface of the earth. The platform is supported by a machine which can give the platform various accelerations while keeping it level. (g = 10 m/s^2)

For what acceleration of the platform does the machine exert the LEAST force on the platform?

(A) zero

(B) 5.0 m/s^2 down

(C) 10 m/s^2 up

(D) 10 m/s^2 down

(E) 20 m/s^2 up

45

S17C
III.1.d
S17C
I.3.c

S 35

F1
A8

(A)

-
***

A 2 kg frictionless puck is at rest on a level table. It is pushed straight north with a constant force for 1.50 s and then let go. The speed then is 3 m/s.

How far does the puck move from rest in 2.25 s?

(A) $\frac{9}{2}$ m

(B) $\frac{81}{16}$ m

(C) $\frac{27}{4}$ m

(D) $\frac{81}{8}$ m

(E) 9 m

46

S17C
III.2.a

S 35

F1
A8

(C)

_
***

An experimenter and some equipment are located on a platform at the surface of the earth. The platform is supported by a machine which can give the platform various accelerations while keeping it level. (g = 10 m/s^2)

The experimenter weighs himself on an ordinary bathroom spring scale and finds that his weight has apparently doubled. The acceleration of the platform must be

(A) 5 m/s^2 up

(B) 10 m/s^2 down

(C) 10 m/s^2 up

(D) 20 m/s^2 up

(E) 20 m/s^2 down

47

S17A
I.2.e
S17C
III.2.a

S 36

F1
A1
A8

(C)

_
**

An object is placed on an equal-arm balance and requires 12 kg to just balance it. When placed on a spring balance the object causes a reading of 12 kg. The balances, set of masses, and the object are transported to the moon. If the force of gravity is 6.0 times greater on the earth than on the moon, the new readings on the balances will be:

(A) equal-arm balance 12 kg, spring balance 12 kg

(B) equal-arm balance 2.0 kg, spring balance 2.0 kg

(C) equal-arm balance 12 kg, spring balance 2.0 kg

(D) equal-arm balance 2.0 kg, spring balance 12 kg

(E) equal-arm balance 12 kg, spring balance 72 kg

48

S17A
I.2.b
S17C
III.1.c

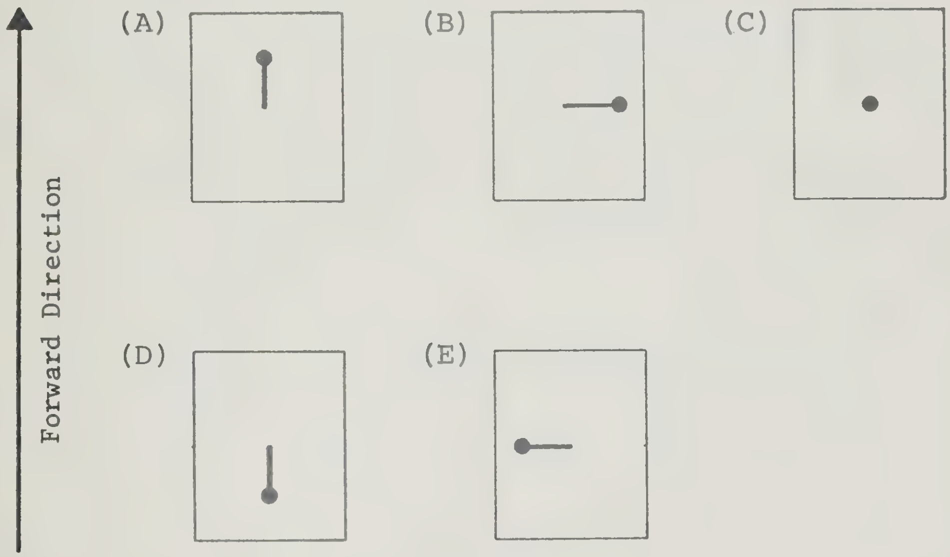
36

F1

(C)

\-
*

A man on a train is seated facing forward. He holds a thread fastened to a lead mass so that the mass is suspended over the center of an open book. The train maintains a speed of 40 km/h for 10 min. Which diagram best represents the position of the lead mass as seen by the man?



49

S17A
I.2.b
S17C
III.1.c

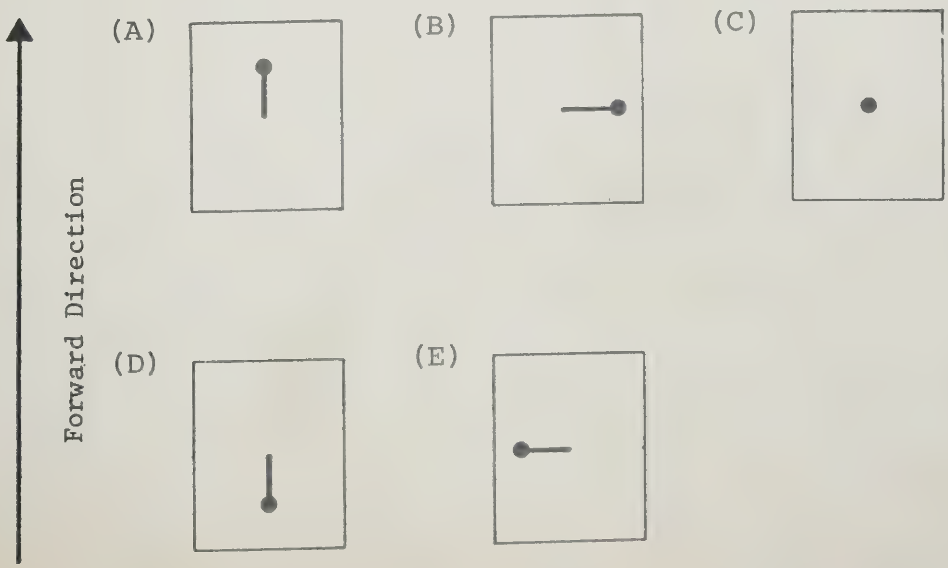
36

F1

(D)

\-
*

A man on a train is seated facing forward. He holds a thread fastened to a lead mass so that the mass is suspended over the center of an open book. The train increases speed from 20 to 40 km/h over a period of 50 s. During this interval, which diagram best represents the position of the lead mass as seen by the man?



50

S17A
I.2.b
S17C
III.1.c

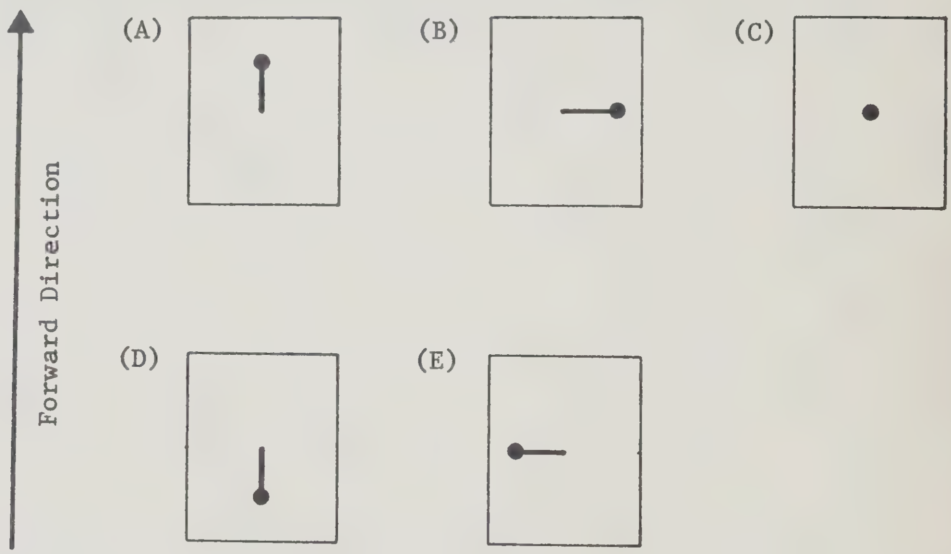
36

F1

(B)

\-
*

A man on a train is seated facing forward. He holds a thread fastened to a lead mass so that the mass is suspended over the center of an open book. The train goes round a curve to the left while maintaining a speed of 40 km/h. Which diagram best represents the position of the lead mass as seen by the man?



51

S17C
III.1.c

S 36

D3
F1

(E)

-
***

A marble is rolled across the smooth floor of a bus which is moving forward in a straight line. The marble is observed to move across the floor and also forward tracing a parabola. Consider the following statements concerning the motion of the bus.

I. It is moving on a level road with constant forward acceleration.

II. It is moving on a level road with constant deceleration.

III. It is moving up a uniform grade with constant speed.

IV. It is moving down a uniform grade with constant speed.

Which of the above statements would account for the observations?

(A) II only

(B) III only

(C) IV only

(D) I and III only

(E) II and IV only

52

S17A
I.2.d
S17C
III.4.b

37

A3
A10

(C)

***
***

A lead mass is suspended by a string held by your hand. The reaction to the force of gravity on the lead is the force exerted by

(A) the string on the lead

(B) the lead on the string

(C) the lead on the earth

(D) the hand on the string

(E) the string on the hand

CENTRIPETAL FORCE

AND GRAVITATION

1 A 500 kg minicar rounds a bend on an unbanked highway at a speed of 20 m/s. The radius of curvature of the bend is 50 m. What is the magnitude of the force that must be exerted on the wheels by the road to keep the car travelling in this curved path without skidding?

S17C
III.2.c
38
F1
(D)
-
**

(A) 0 N

(B) 0.20 kN

(C) 3.2 kN

(D) 4.0 kN

(E) 5.0 kN

2 An object moves in a circular path at constant speed. If the radius of the path is doubled but the speed remains the same, the centripetal force is

S17C
III.2.c
38
F1
(B)
-
**

(A) twice as great

(B) half as great

(C) four times as great

(D) one fourth as great

(E) unchanged

3 The driver of a 1000 kg car tries to turn through a circle of radius 100 m on an unbanked curve at a speed of 10 m/s. The force of friction between the road and car wheels is 900 N. The car will

S17C
III.2.c
38
F1
(E)
-
***

(A) slide into the inside of the curve

(B) make the turn and could go even faster

(C) make the turn, but at its maximum safe speed

(D) make the turn if it increases speed

(E) slide off to the outside of the curve

4 A rubber ball moves at constant speed in a horizontal circular path. A centripetal force of 20 N causes the ball to move in a circle of 1 m radius at a frequency of 4 Hz. If the centripetal force were 20 N and the radius 0.25 m, the frequency of rotation would be

S17C
III.2.c
38
F1
A8
(D)
-
***

(A) 1 Hz

(B) 2 Hz

(C) 4 Hz

(D) 8 Hz

(E) 16 Hz

5 A rubber ball moves at constant speed in a horizontal circular path. A centripetal force of 20 N causes the ball to move in a circle of 1 m radius at a frequency of 4 Hz. If the centripetal force were 80 N and the radius 1 m, the frequency of rotation would be

S17C
III.2.c
38
F1
A8
(D)
-
***

(A) 1 Hz

(B) 2 Hz

(C) 4 Hz

(D) 8 Hz

(E) 16 Hz

6

S17C
III.2.c

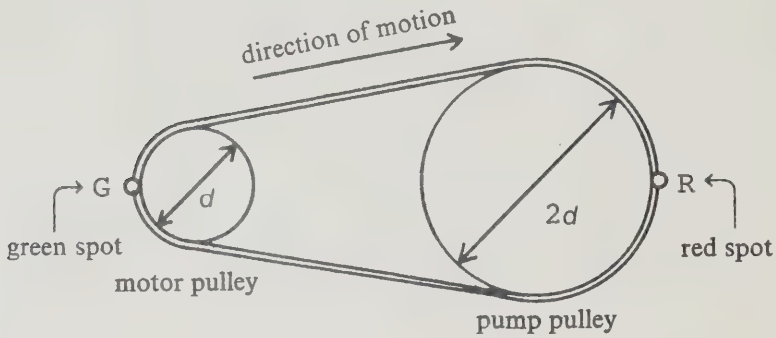
S 38

F1
A8
A11

(B)

***

The diagram shows a motor driving a pump by means of a belt. The pump pulley diameter is twice the motor pulley diameter. There is a red spot (R) and a green spot (G) on the belt.



Which one of the following equations correctly relates the magnitudes of the acceleration (a_G) of the green spot and the acceleration (a_R) of the red spot at the time shown?

(A) $a_G = 4a_R$

(B) $a_G = 2a_R$

(C) $a_G = a_R$

(D) $a_G = \frac{a_R}{2}$

(E) $a_G = \frac{a_R}{4}$

7

S17C
III.2.c

38

A8
F1

(C)

-
**

Several masses m are determined to be equal by comparing them on an equal-arm balance, and a large mass M is found just to balance two of the small ones on a similar balance.

The mass M and one of the masses m are each forced to go around a curve of 1.0 m radius at a constant speed of 1.0 m/s. As they move around this curve the magnitudes of the forces acting on them are

(A) equal

(B) in the ratio of 4 to 1

(C) in the ratio of 2 to 1

(D) zero

(E) none of the above

8

S17C
III.2.c

38

F1
A8

(B)

-
***

An object is made to move in a circular orbit by a centripetal force F. If the mass is tripled and the speed halved while the radius is kept constant, the force required is

(A) $\frac{3F}{2}$

(B) $\frac{3F}{4}$

(C) $\frac{9F}{4}$

(D) $6F$

(E) $12F$

9

S17C
III.2.b

38

A1
A8

(A)

-
**

Several masses *m* are determined to be equal by comparing them on an equal-arm balance, and a large mass *M* is found just to balance two of the small ones on a similar balance.

The mass *M* and one of the masses *m* are each forced to go around a curve of 1.0 m radius at a constant speed of 1.0 m/s. As they move around the curve their accelerations are

(A) equal

(B) along the direction of motion

(C) in the ratio of 2 to 1

(D) zero

(E) in the ratio of 4 to 1

10

S17C
III.2.b

38

F1

(E)

-
***

A 2 kg stone at the end of a string 1.0 m long is whirled in a vertical plane with an average speed of 4.0 m/s. The tension in the string when the stone is at the bottom of the circle is

(A) 0 N

(B) 12 N

(C) 20 N

(D) 32 N

(E) 52 N

11

S17C
III.3.b

40

A8

(E)

***
***

If the separation between the centres of two masses is reduced to 1/3 of its former value, the gravitational force between them changes by a factor of

(A) 1/9

(B) 1/3

(C) 3

(D) 6

(E) 9

12

S17C
III.3.b

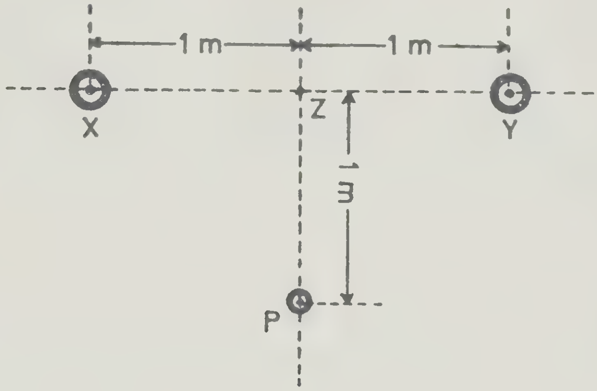
40
56

A8
F1

(D)

***

Two metal spheres, each of mass 5 kg, are fixed in position at points X and Y as shown in the diagram below. A third sphere of mass 0.01 kg is released from rest at point P and is affected only by the forces of gravitational attraction exerted on it by the masses at points X and Y. Point Z is located exactly midway between points X and Y.



After the smaller mass is released from point P, the mass will

(A) move with constant speed

(B) move with constant velocity

(C) move with constant acceleration

(D) move with varying acceleration

(E) undergo a change in total energy

13

S17A
I.2.e
S17C
III.3.b

40

A8
F1

(A)

–
***

System	Mass X (kg)	Mass Y (kg)	Separation (m)	Gravitational Force (N)
I	1	4	2	F
II	2	8	8	?

With reference to the data above, the gravitational force between the two masses X and Y in System II in newtons must be

(A) $\frac{F}{4}$

(B) $\frac{F}{2}$

(C) F

(D) $2F$

(E) $4F$

14

S17A
I.2.e
S17C
III.3.b

40

A8
F1

(E)

***
**

A boy and a girl are sitting in the cafeteria eating lunch. They move so that the distance between them is now one-quarter as great as it was before. The force of attraction between them (gravitational, that is) is now about

(A) one-sixteenth as great

(B) one-quarter as great

(C) four times as great

(D) eight times as great

(E) sixteen times as great

15

S17A
I.2.e
S17C
III.3.b

40

A8
F1

(A)

***
**

Assume that the earth suddenly shrank to one-half its original diameter, but that its mass remained unchanged. Under these circumstances, the force of gravity on a person standing on the earth's surface would be

(A) four times as great

(B) twice as great

(C) the same

(D) one-half as great

(E) one-fourth as great

16

S17A
I.2.e
S17C
III.3.b

40

A8
F1

(A)

***
***

Two sacks of marbles are hung one metre apart. Which of the following would approximately double the gravitational force that one sack of marbles exerts on the other sack?

(A) doubling the number of marbles in one sack only

(B) doubling the number of marbles in both sacks

(C) moving them closer, to one-half the separation

(D) moving them further apart, to twice the separation

(E) moving them further apart, to four times the separation

17

S17A
I.2.e
S17C
III.3.b

40

F1
A8

(A)

**
***

An object on the surface of the earth (at a distance R from the centre) experiences a gravitational force of 90 N. At a distance of $3R$ from the centre of the earth the same object will experience a force of

(A) 10 N

(B) 30 N

(C) 90 N

(D) 270 N

(E) 810 N

18 Which one of the following graphs best represents gravitational force F versus distance r for a rocket leaving the earth?

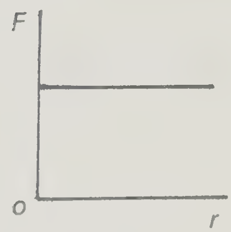
S17A
I.2.e
S17C
III.3.b

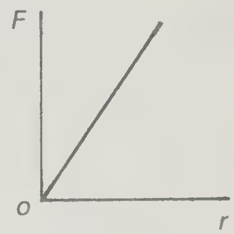
40

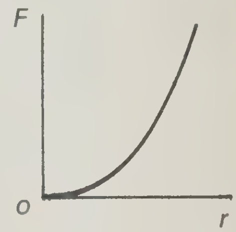
A11
A8

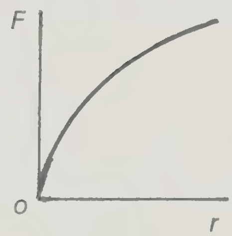
(E)

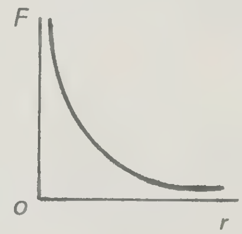
***
***

(A)


(B)


(C)


(D)


(E)


19 An astronaut experiences a force of gravity of 1000 N on Venus. Uranus has 18 times the mass and 4 times the radius of Venus. The force of gravity, in newtons, that the astronaut would experience on Uranus is

S17A
I.2.e
S17C
III.3.b

40

F1
A8

(D)

**
**

(A) 1000

(B) $1000 \times \frac{18}{4}$

(C) $1000 \times \frac{4}{18}$

(D) $1000 \times \frac{18}{16}$

(E) $1000 \times \frac{16}{18}$

20

S17C
III.3.b

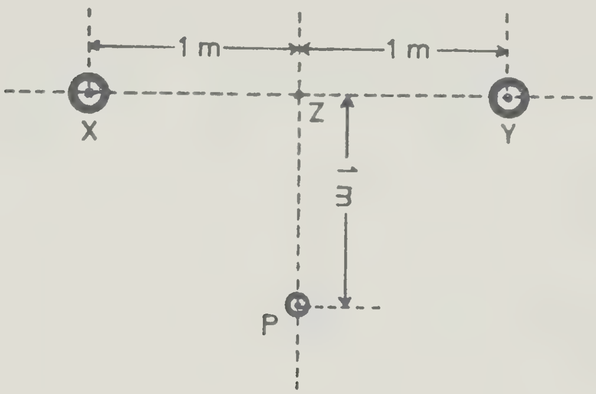
40

F1
A8

(E)

***

Two metal spheres, each of mass 5 kg, are fixed in position at points X and Y, as shown in the diagram below. A third sphere of mass 1/100 kg is released from rest at point P and is affected only by the forces of gravitational attraction exerted on it by the masses at points X and Y. Point Z is located exactly midway between points X and Y. The gravitational constant is represented by the symbol "G".



The gravitational force, in newtons, exerted by <u>each one</u> of the 5 kg masses on the smaller mass at the instant it is released from point P is

(A) $\frac{25 \times G}{2}$

(B) $\frac{25 \times G}{4}$

(C) $\frac{5 \times G}{2}$

(D) $\frac{2 \times G}{40}$

(E) $\frac{G}{40}$

21

S17A
I.2.e
S17C
III.3.b

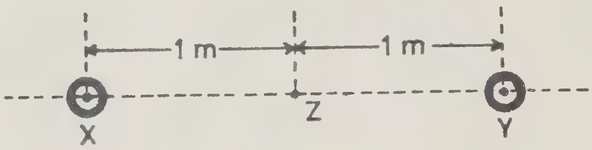
40
24

F1
A8

(E)

-
***

Two metal spheres, each of mass 5 kg, are fixed in position at points X and Y as shown in the diagram below. A third sphere of mass 1/100 kg is released from rest at point Z and is affected only by the forces of gravitational attraction exerted on it by the masses at points X and Y. Point Z is located exactly midway between points X and Y. The gravitational constant is represented by the symbol "G".



The net force, in newtons, acting on the smaller mass at the instant of release would be

(A) 25 x G

(B) 10 x G

(C) $\frac{G}{10}$

(D) $\frac{G}{20}$

(E) zero

22

S17A
I.2.e
S17C
III.3.b

40

F1
A8

(B)

-
***

The force of gravity on a mass at two earth radii from the centre of the earth is 200 N. The force, in newtons, on this mass at a distance of ten earth radii from the earth's centre would be

(A) 2

(B) 8

(C) 20

(D) 40

(E) 2000

23

S17A
I.2.e
S17C
III.3.b

S 40

A3

(C)

**
-

An object is raised from the surface of the earth to a height of two earth radii. Which of the following is correct?

(A) The mass of the object decreases and the force of gravity on the object remains constant.

(B) The mass of the object and the force of gravity on the object both remain constant.

(C) The mass of the object remains constant and the force of gravity on the object decreases.

(D) Both the mass and the force of gravity on the object decrease.

(E) The mass of the object remains constant and the force of gravity on the object increases.

24

S17C
III.3.b

S 40

F1
A8

(A)

-
***

A satellite is placed in a circular orbit about the earth at a height of 100 km above the surface. If the earth's radius is 6400 km, the value of the gravitational field at the satellite is approximately

(A) $\left(\frac{6400}{6500}\right)^2 \times 10\ \text{m/s}^2$

(B) $\left(\frac{6500}{6400}\right)^2 \times 10\ \text{m/s}^2$

(C) $\left(\frac{6400}{6500}\right) \times 10\ \text{m/s}^2$

(D) $\left(\frac{6500}{6400}\right) \times 10\ \text{m/s}^2$

(E) $10\ \text{m/s}^2$

IMPULSE AND CONSERVATION OF MOMENTUM

1 What impulse will give a 2.0 kg mass a momentum change of +50 kg·m/s?

S17C
III.4.a

42

A3
A8
F1

(C)

-

***

(A) +25 N·s

(B) -25 N·s

(C) +50 N·s

(D) -50 N·s

(E) +100 N·s

2 A 2 kg frictionless puck is at rest on a level table. It is pushed straight north with a constant force for 1.50 s and then let go. The speed then is 3 m/s. The momentum of the puck at the end of 1.50 s is

S17C
III.4.a

42

F1
A8

(E)

-

**

(A) 3 kg·m/s

(B) 3 kg·m·s north

(C) 6 kg·m/s

(D) 6 kg·m·s north

(E) 6 kg·m/s north

3

S17C
III.4.a

42

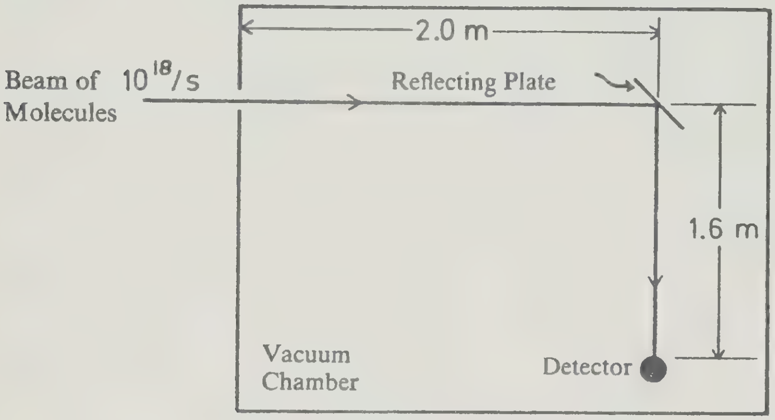
F1
A8

(C)

-

***

A beam containing 1.0 x 10^{18} molecules/s enters a vacuum chamber. After tracing out the path shown each molecule is absorbed by the detector. Each molecule has a mass of 5.0 x 10^{-26} kg and travels at a speed of 2.0 x 10^{3} m/s. NOTE: The only function of the reflecting plate is to change the direction of the beam of molecules.



The magnitude of the change of a molecule's momentum caused by its interaction with the reflecting plate is

(A) 0 kg·m/s

(B) 1.0 x 10^{-22} kg·m/s

(C) 1.4 x 10^{-22} kg·m/s

(D) 2.0 x 10^{-22} kg·m/s

(E) 2.6 x 10^{-22} kg·m/s

4

S17C
III.4.a

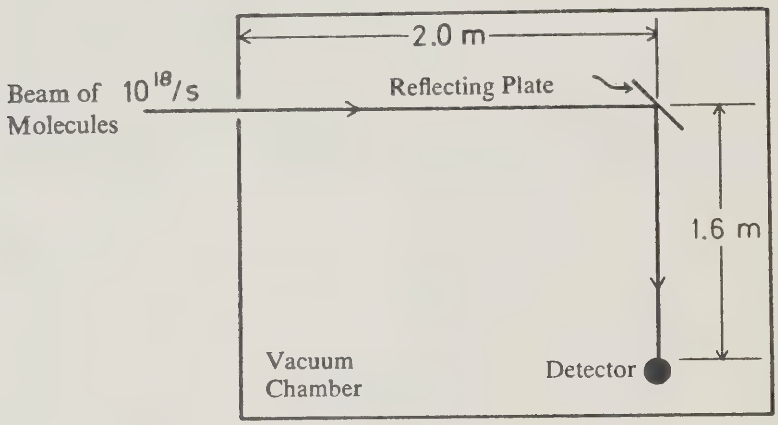
42

F1
A8

(B)

\-
**

A beam containing 1.0×10^{18} molecules/s enters a vacuum chamber. After tracing out the path shown each molecule is absorbed by the detector. Each molecule has a mass of 5.0×10^{-26} kg and travels at a speed of 2.0×10^{3} m/s. NOTE: The only function of the reflecting plate is to change the direction of the beam of molecules.



The impulse exerted on the detector by each molecule is

(A) 0 N·s

(B) 1.0×10^{-22} N·s

(C) 1.4×10^{-22} N·s

(D) 2.0×10^{-22} N·s

(E) 2.6×10^{-22} N·s

5

S17C
III.3.a

42

F1

(A)

_
**

A 0.20 kg rubber ball, initially at rest, is dropped from the window of a building. It strikes the sidewalk below with a speed of 30 m/s and rebounds from the sidewalk with a speed of 20 m/s. (Ignore any effect due to air friction.)

The magnitude of the change in momentum of the ball as a result of the impact with the sidewalk is

(A) 10 kg·m/s

(B) 6.0 kg·m/s

(C) 4.0 kg·m/s

(D) 2.0 kg·m/s

(E) 1.0 kg·m/s

6

S17C
III.3.b

42

F1

(D)

_
***

A 75 kg man was riding on a 30 kg cart travelling at a speed of 2.0 m/s relative to the ground. He jumped off in such a way that he landed on the ground with no horizontal speed. What was the resulting <u>change</u> in the speed of the cart?

(A) 0

(B) 2.0 m/s

(C) 3.0 m/s

(D) 5.0 m/s

(E) 7.0 m/s

7

S17C
III.4.a

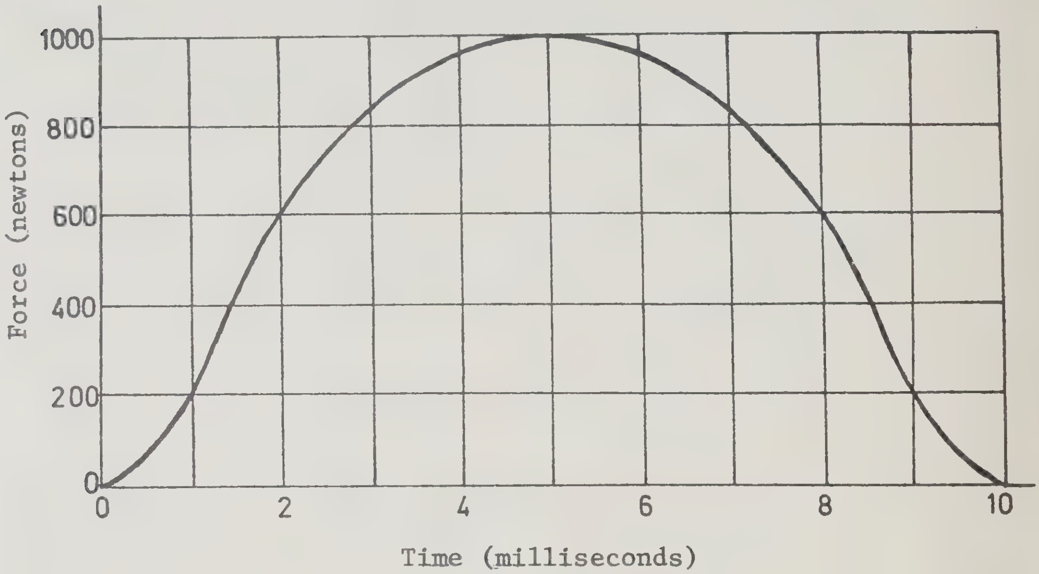
42

A11
F1

(C)

–
***

The graph below shows the variation in the force exerted on a tennis ball by a tennis racket during the time the two are in contact.



The magnitude of the total impulse given the ball by the racket is approximately

(A) 31 N·s

(B) 5 N·s

(C) 6 N·s

(D) 6×10^3 N·s

(E) 3 N·s

8

S17C
III.4.a

42

F1
A8

(C)

\-
***

A 2 kg frictionless puck is moving straight north with a speed of 3 m/s. The puck is pushed east by a constant force of 4 N. How many seconds after the application of this force is the puck moving exactly north east?

(A) $\frac{1.50}{\sqrt{2}}$ s

(B) $1.50\sqrt{2}$ s

(C) 1.50 s

(D) 2.75 s

(E) 4.25 s

9

S17C
III.4.a

42

F1
A8

(B)

\-
***

A 2 kg frictionless puck is moving straight north with a speed of 3 m/s. The puck is pushed east by a constant force of 4 N for 2.0 s. At the end of this time how fast will the puck be moving?

(A) 4 m/s

(B) 5 m/s

(C) 7 m/s

(D) 8 m/s

(E) 10 m/s

10

S17C
III.4.a

42

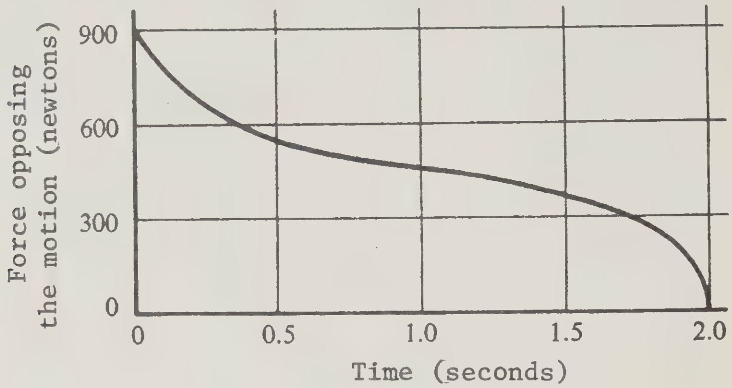
A7
A8
F1

(B)

\-

***

An object moving at 15 m/s comes to a stop in 2 s. The variation in the stopping force is shown in the diagram below.



The mass of the object is

(A) 30 kg

(B) 60 kg

(C) 90 kg

(D) 120 kg

(E) 180 kg

11

S17C
III.4.b

43

A8
F1

(C)

\-

***

A rifle of mass M is initially at rest but free to recoil. It fires a bullet of mass m with a velocity v relative to the ground. After firing, the velocity of the rifle relative to the ground is

(A) $-mv$

(B) $\dfrac{-mv}{M+m}$

(C) $\dfrac{-mv}{M}$

(D) $-v$

(E) $\dfrac{mv}{M}$

12

S17C
III.4.b

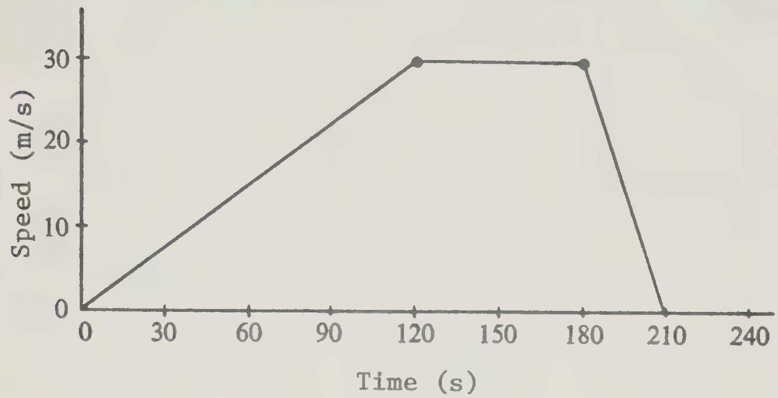
43

A8
F1

(B)

-
***

The graph below shows the speed as a function of time for an automobile with a mass of 1.5×10^3 kg. The brakes were applied at $t = 180$ s.



Suppose that 10 s after the brakes were applied, the automobile struck an icy surface and collided head on with a stationary truck. The two moved on together with a speed one-third that of the car before the collision. The mass of the truck must have been approximately

(A) 1.5×10^3 kg

(B) 3.0×10^3 kg

(C) 4.5×10^3 kg

(D) 6.0×10^3 kg

(E) 7.5×10^2 kg

13

S17C
III.4.b

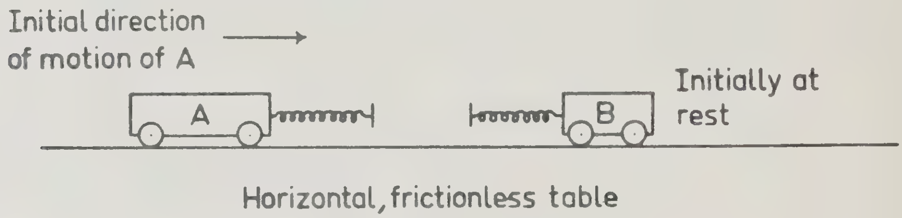
43

F1
A8

(D)

\-
**

Two carts, A and B, having spring bumpers, undergo an elastic collision. Cart A has a mass of 75 kg and is initially moving to the right with a speed of 6.0 m/s. Cart B is initially at rest and its mass is not known. Consider all motion to the right as being positive, and assume that during the collision interval the two carts exert a constant repulsion of 150 N on each other.



What is the total momentum of carts A and B relative to the table <u>after</u> the collision?

(A) Zero

(B) 225 kg·m/s

(C) 300 kg·m/s

(D) 450 kg·m/s

(E) It cannot be determined without additional information.

14

S17C
III.4.b

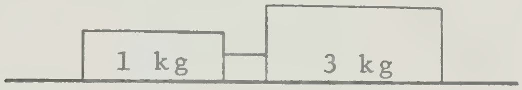
43

A8
F1

(E)

-
***

A 1 kg mass and a 3 kg mass joined by a thread of negligible mass travel together in a straight line at constant speed v over a frictionless surface. The string is suddenly cut, after which the speeds of the 1 kg mass and the 3 kg mass are designated v' and v'' respectively.



The final speeds are given by

(A) $v'' = \frac{1}{3}v, \quad v' = \frac{2}{3}v$

(B) $v'' = \frac{2}{3}v, \quad v' = \frac{1}{3}v$

(C) $v'' = \frac{3}{4}v, \quad v' = \frac{1}{4}v$

(D) $v'' = \frac{1}{4}v, \quad v' = \frac{3}{4}v$

(E) none of these

15 The diagram below shows the velocity-time graph for two masses S and T that collided elastically.

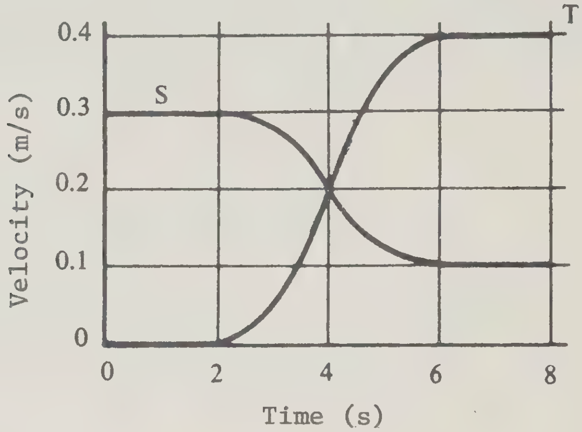
S17C
III.4.b

43

A11
A2
A8

(E)

\-
***



Which one of the following statements <u>contradicts</u> the facts implied in the graph?

(A) S and T moved in the same direction after the collision.

(B) The interaction lasted for approximately 4 s.

(C) The mid-time of the interaction was at t = 4 s.

(D) The velocities of S and T were equal at the mid-time of the collision.

(E) The mass of T was greater than the mass of S.

16

S17C
III.4.a

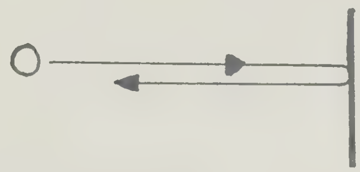
43

F1

(E)

\-
***

The ball of mass 2 kg moving with a horizontal velocity of 5 m/s to the right hits a vertical wall and rebounds with a horizontal velocity of 4 m/s to the left as shown in the diagram below.



The magnitude of the change in momentum of the ball, in kg·m/s, is

(A) 2

(B) 5

(C) 9

(D) 10

(E) 18

17

S17C
III.4.b

43

F1
A8

(A)

\-
**

A 0.1 kg snowball strikes a 0.9 kg stationary skateboard and sticks to it. At the instant of impact, the snowball had a velocity of 18 m/s west. (Assume that the skateboard is on a horizontal stretch of ground and that it moves without friction.) After collision, the skateboard and snowball move with a velocity of

(A) 1.8 m/s west

(B) 2.0 m/s west

(C) 16.2 m/s west

(D) 162 m/s west

(E) 180 m/s west

18

S17C
III.4.b

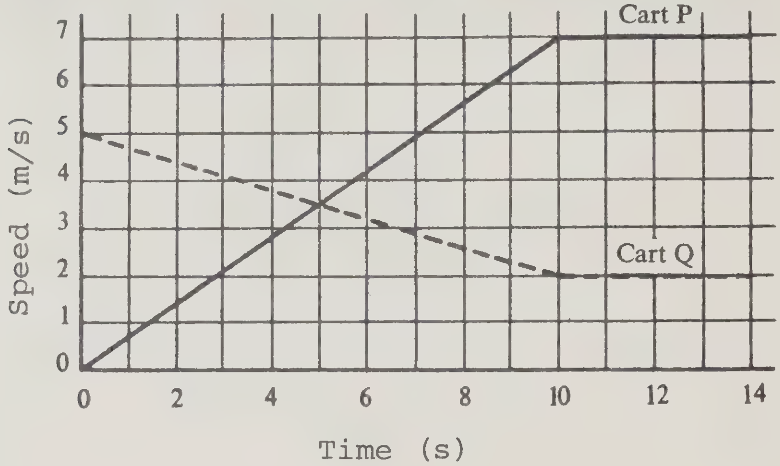
43

A8
F1

(E)

\-
***

Carts P and Q have a head-on elastic collision. Their speed-time graphs are shown below.



The ratio of the mass of cart P to that of cart Q is

(A) 7:2

(B) 2:7

(C) 7:5

(D) 1:1

(E) 3:7

19

S17C
III.4.b

44

F1
A8

(A)

\-
***

A body of mass 8.0 kg is moving due east with a uniform speed of 5.0 m/s. It suddenly explodes into two parts having masses of 5.0 kg and 3.0 kg. Just after the explosion, the 3.0 kg mass has a velocity of 15 m/s due east relative to the earth's surface. The speed of the 5.0 kg mass relative to the earth's surface will be most nearly

(A) 1.0 m/s

(B) 4.0 m/s

(C) 7.0 m/s

(D) 9.0 m/s

(E) 10.0 m/s

20

S17C
III.4.b

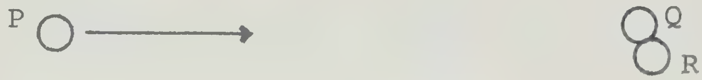
44

F1
A8

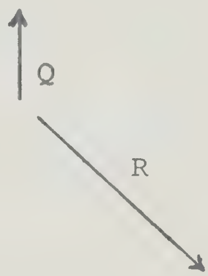
(E)

\-
***

Three balls are in the position shown. Ball P has a momentum represented by the vector shown. Balls Q and R are at rest.



After collision balls Q and R have momenta represented by the vectors shown immediately below.



Which of the following vectors most nearly represents the momentum of ball P after the collision?

(A) 

(B) 

(C) 

(D) 

(E) 

21

S17C
III.4.b

44
24

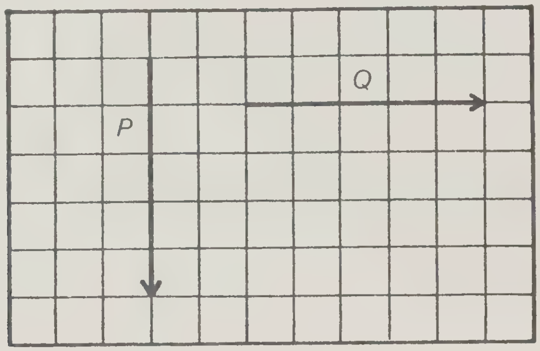
A8
A7
F1
A11

(D)

-

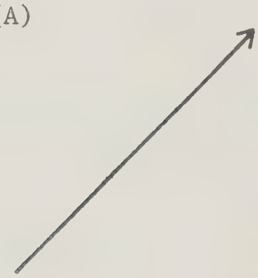
**

Two bodies of unequal mass have momenta *P* and *Q* as indicated in the diagram below. They collide and stick together.

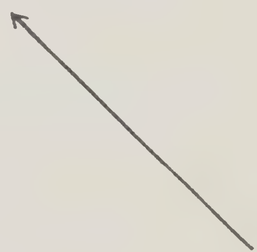


After collision, the momentum of the combined bodies will best be represented by

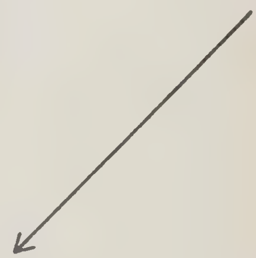
(A)



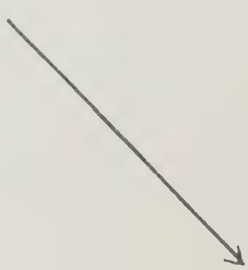
(B)



(C)



(D)



(E) a vector which depends on the relative masses

22

S17C
III.5.d

44
54

F1
A8

(A)

\-
***

A 1 kg ball moving at 2 m/s collides elastically with a stationary ball of mass 3 kg. During the collision the total kinetic energy decreases and then returns to its original value.

Which of the following statements correctly describes the system when the kinetic energy reaches a minimum?

(A) The speeds of the two balls are equal.

(B) The kinetic energies of the two balls are equal.

(C) The momentum of each ball is the same.

(D) The potential energy stored in the system equals the total kinetic energy.

(E) The total momentum of the system is a minimum.

23

S17C
III.5.c

S 45
43

D3
A8

(B)

\-
***

Two carts having the same mass travel toward each other, each with a speed of 1 m/s relative to the surface. The carts collide head on and are reported to rebound after collision, each with a speed of 2 m/s relative to the surface.

Which one of the following assessments of this report is correct?

(A) Momentum was not conserved, therefore the report is false.

(B) If potential energy was released to the carts during the collision, the report could be true.

(C) If the carts had different masses, the report could be true.

(D) If the surface was inclined, the report could be true.

(E) If there was no friction between the carts and the surface, the report could be true.

WORK AND KINETIC ENERGY

1

Which one of the following quantities is a vector quantity?

S17A
I.3.b
S17C
III.5.a

S 45

A2

(E)

**

-

(A) mass

(B) volume

(C) energy

(D) time

(E) acceleration

2

In order to compare the kinetic energies of two objects moving horizontally it is sufficient to compare only

S17C
III.5.b
S17C
III.4.a

45

A8

(E)

-

***

(A) their masses

(B) their velocities

(C) their momenta

(D) the impulses necessary to stop each of them

(E) the work necessary to stop each of them

3

S17C
III.5.b
S17C
III.4.a

S 46
4

F1
A7

(E)

-
***

The expression $\frac{6.6 \times 10^{-34}\ \text{J}\cdot\text{s}}{9.1 \times 10^{-31}\ \text{kg} \times 3.3 \times 10^{-10}\ \text{m}}$ appeared in the solution to a physics problem. According to the units, the student was calculating

(A) an amount of energy

(B) a force

(C) an acceleration

(D) a momentum

(E) a speed

4

S17C
III.5.a

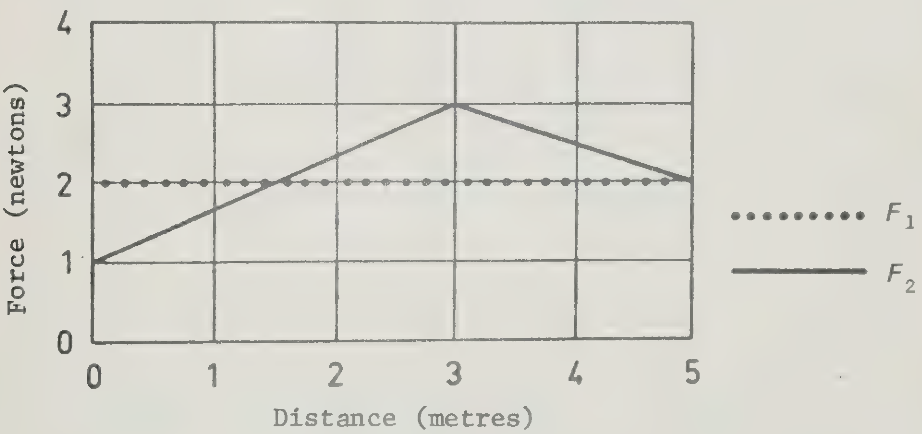
47

F1
A7

(B)

-
**

The graph below shows the forces F_1 and F_2 applied to two identical masses m_1 and m_2, respectively. Both masses were originally at rest.



At what distance has an equal amount of work been done by the two forces?

(A) 1.5 m

(B) 3 m

(C) 5 m

(D) At all distances in the range shown.

(E) At no distance in the range shown, other than 0 m.

5

S17C
III.5.b

47

F1
A8

(C)

-
***

The speed of a kilogram mass increases uniformly from 20 m/s at point P to 40 m/s at point Q along a straight horizontal path PQR. From Q to R the mass slows down uniformly, coming to rest at R. The time taken by the mass in travelling from Q to R is ten times that taken from P to Q. The work done on the mass from P to Q is

(A) 200 J

(B) 400 J

(C) 600 J

(D) 800 J

(E) 1200 J

6

S17A
I.3.d
S17C
III.6.c

47

A3
F1

(C)

***
***

A girl exerts a 200 N force to lift a barbell to a vertical height of 2.0 m in 5.0 s. If she had done this in 10 s, the energy required would have been

(A) four times as great

(B) twice as great

(C) the same

(D) half as great

(E) one quarter as great

7

S17A
I.3.a
S17C
III.5.a

47

F1

(B)

***
***

A man applies a force of 220 N horizontally to the right against a 50 kg crate. The force of friction between the crate and floor is 200 N. If the crate is pushed 2.0 m, the total work done on the crate is

(A) 840 J

(B) 440 J

(C) 400 J

(D) 40 J

(E) zero

8

S17A
I.3.a
S17C
III.5.a

47

F1
A8

(C)

***
**

A man applies a force of 220 N horizontally to the right against a 50 kg crate. The force of friction between the crate and floor is 200 N. If the crate is pushed 2.0 m, the work done against friction is

(A) 840 J

(B) 440 J

(C) 400 J

(D) 200 J

(E) 40 J

9

S17A
I.3.d

47
48

A3
A8

(C)

**

-

Person X is able to lift a 50 kg barbell to a height of 2.0 m in 1.0 s. If Person Y takes 1.5 s to do the same thing, then, in this lift

(A) X does more work than Y

(B) Y does more work than X

(C) X develops more power than Y

(D) Y develops more power than X

(E) X and Y develop the same power

10

S17C
III.6.a

S 47

F1
A8

(C)

-
***

One end of an ideal spring is attached to a support and the other end is free. It is found that 50 J of work must be done to pull the free end 0.3 m from its rest position. How much <u>additional</u> work is required to pull the free end an additional 0.3 m?

(A) 50 J

(B) 100 J

(C) 150 J

(D) 200 J

(E) 250 J

11

S17C
III.6.a

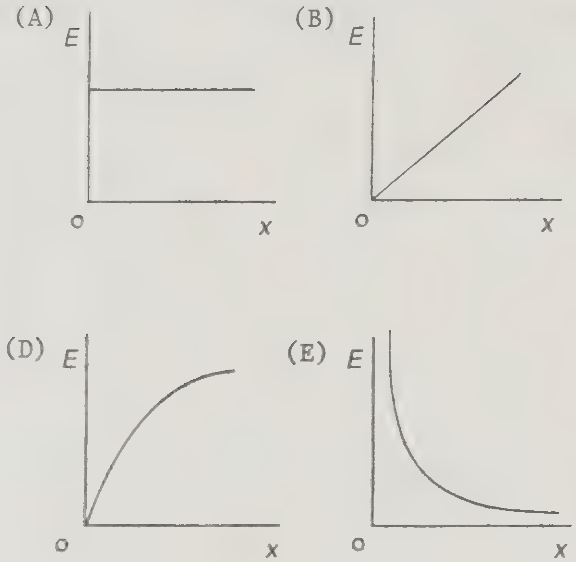
S 47

A11
A8

(C)

–
***

Which one of the following graphs best represents stored energy, *E*, versus extension, *x*, for a normal coil spring?



12

S17C
III.6.a

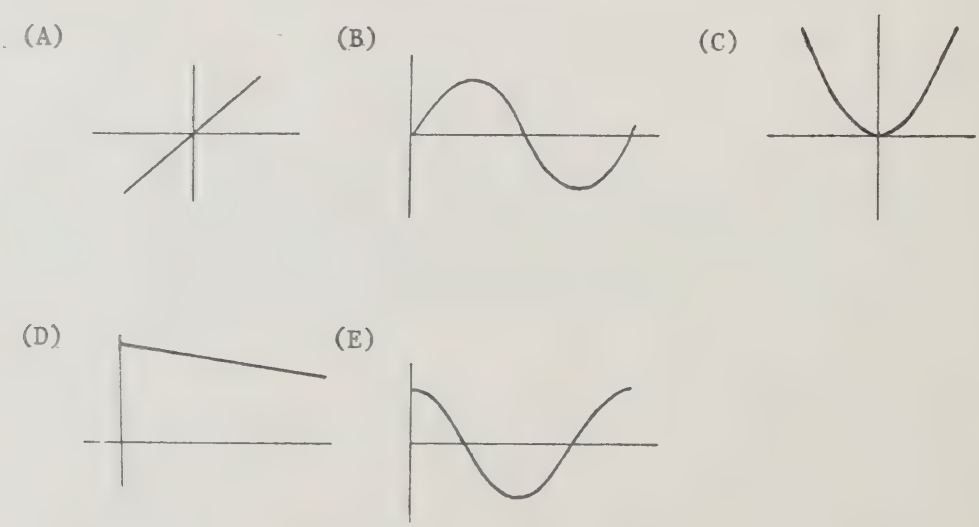
S 47

A11
A8

(A)

–
***

The following graphs refer to the up and down motion of a small mass hung on a vertical coil spring. Which graph below best represents the restoring force as a function of displacement?



13

S17C
III.6.a

S 47

A11
A8

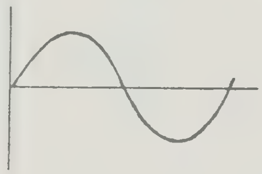
(C)

\-
***

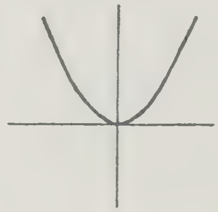
The following graphs refer to the up and down motion of a small mass hung on a vertical coil spring. Which graph below best represents the elastic potential energy as a function of displacement from equilibrium?

(A)

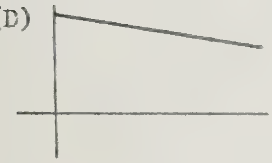
(B)



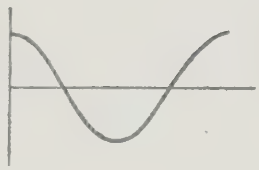
(C)



(D)



(E)



14

S17C
III.6.a

S 47

F1
A8

(B)

\-
***

A 10 N force is compressing a spring which has a force constant of 20 N/m. The potential energy stored in the spring is

(A) 0.5 J

(B) 2.5 J

(C) 5 J

(D) 10 J

(E) 200 J

15

S17C
III.6.a

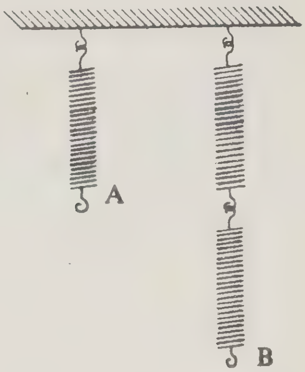
S 47

F1
A8

(E)

–
***

Three identical ideal springs are arranged as shown in the figure below. When a 4 kg mass is hung on A, the mass descends 3.0 cm.



When a mass of 6 kg is hung on B, the mass descends

(A) 2.0 cm

(B) 4.0 cm

(C) 4.5 cm

(D) 6.0 cm

(E) 9.0 cm

16

S17C
III.6.a

S 47

A8
F1

(E)

–
***

As a result of the compression of a spiral spring, U units of potential energy are added to it. When this spring is allowed to elongate 2/3 of the distance it was compressed, its remaining potential energy in the same units will be

(A) $\frac{2}{3}U$

(B) $\frac{4}{9}U$

(C) $\frac{1}{3}U$

(D) $\frac{1}{\sqrt{3}}U$

(E) $\frac{1}{9}U$

17

S17A
I.3.d
S17C
III.6.c

49

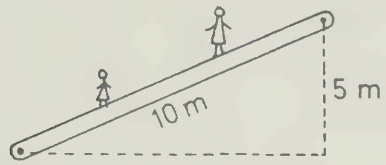
A8

(C)

-

***

The escalator shown below is used to move 20 passengers a minute from the first floor of a department store to the second, 5 m above.



If the average mass of the passengers is 60 kg, the power required to move them is approximately

(A) 100 W

(B) 200 W

(C) 1000 W

(D) 2000 W

(E) 60 000 W

18

S17A
I.3.d

49

A3
F1

(C)

**

-

A 50 W light bulb operating for 20 s uses the same amount of energy as a 100 W bulb operating for

(A) 2.0 s

(B) 5.0 s

(C) 10 s

(D) 20 s

(E) 40 s

19

S17A
I.3.b
S17C
III.5.b

52

F1

(D)

***
**

A man applies a force of 220 N horizontally to the right against a 50 kg crate. The force of friction between the crate and floor is 200 N. If the crate is pushed 2.0 m, the kinetic energy gained by the crate is

(A) 840 J

(B) 440 J

(C) 400 J

(D) 40 J

(E) zero

20

S17C
III.5.b

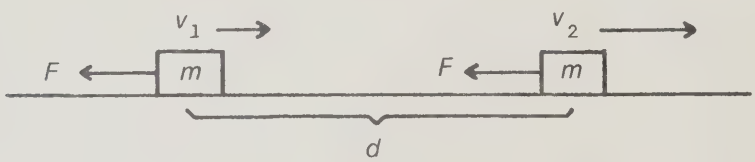
52

F1
A8

(E)

\-
***

A mass m moving with speed v_1 has a constant force of friction F acting on it.



In order to increase its speed to v_2 over a distance d, the total work that must be done is

(A) Fd

(B) $\frac{1}{2}mv_2^2$

(C) $\frac{1}{2}m(v_2^2 - v_1^2)$

(D) $\frac{1}{2}m(v_2 - v_1)^2 + Fd$

(E) $\frac{1}{2}m(v_2^2 - v_1^2) + Fd$

21

S17C
III.4.a
S17C
III.5.b

52
42
53

A3
A8
F1

(D)

_
***

Two objects have the same momentum but do not have the same mass. Consider the following statements about them:

I. The one with less mass has more kinetic energy.

II. The same work was done to accelerate each from rest.

III. Both deliver the same impulse when stopped.

Which of the above statements is/are correct?

(A) I only

(B) II only

(C) III only

(D) I and III only

(E) II and III only

22

S17A
I.3.b
S17C
III.5.b

53
S 3

F1
A8

(B)

_
***

The order of magnitude of the kinetic energy of a proton having mass 2×10^{-27} kg and travelling at 3×10^{6} m/s is

(A) 10^{-11} J

(B) 10^{-14} J

(C) 10^{-15} J

(D) 10^{-18} J

(E) 10^{-21} J

23

S17A
I.3.b
S17C
III.5.b

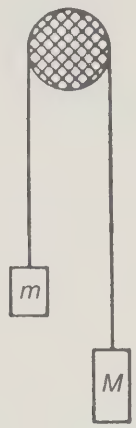
53

F1
A8

(E)

-
***

Two masses $m = 2$ kg and $M = 3$ kg are joined by a cord which passes over a smooth support. The system is initially held at rest and then released. Take $g = 10$ m/s^2; neglect friction and the mass of the cord.



If the mass M has an instantaneous speed of 4 m/s the kinetic energy of the system is

(A) 6 J

(B) 8 J

(C) 10 J

(D) 24 J

(E) 40 J

24

S17C
III.5.b

S 53

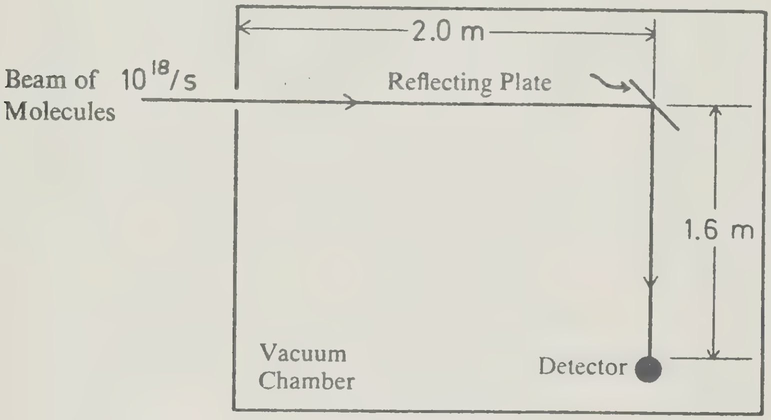
F1
A8

(D)

-

***

A beam containing 1.0×10^{18} molecules/s enters a vacuum chamber. After tracing out the path shown each molecule is absorbed by the detector. Each molecule has a mass of 5.0×10^{-26} kg and travels at a speed of 2.0×10^{3} m/s. NOTE: The only function of the reflecting plate is to change the direction of the beam of molecules.



The energy absorbed per second by the detector is

(A) 1.0×10^{-19} J

(B) 2.0×10^{-19} J

(C) 5.0×10^{-5} J

(D) 1.0×10^{-1} J

(E) 2.0×10^{-1} J

25

S17C
III.5.b
S17C
I.3.c

53
19

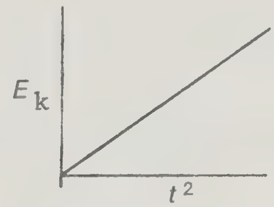
All

(A)

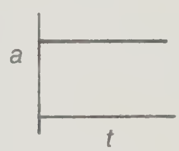
\-

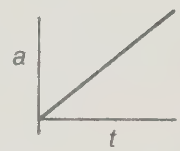
***

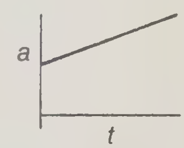
The kinetic energy E_k of a particle varies with the square of the time according to the graph shown.

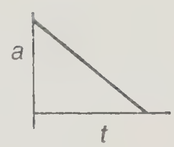


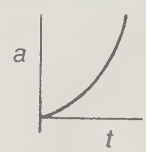
Which of the graphs below best depicts the acceleration a of the particle as a function of time t?

(A)


(B)


(C)


(D)


(E)


26

S17A
I.3.b
S17C
III.5.b

53

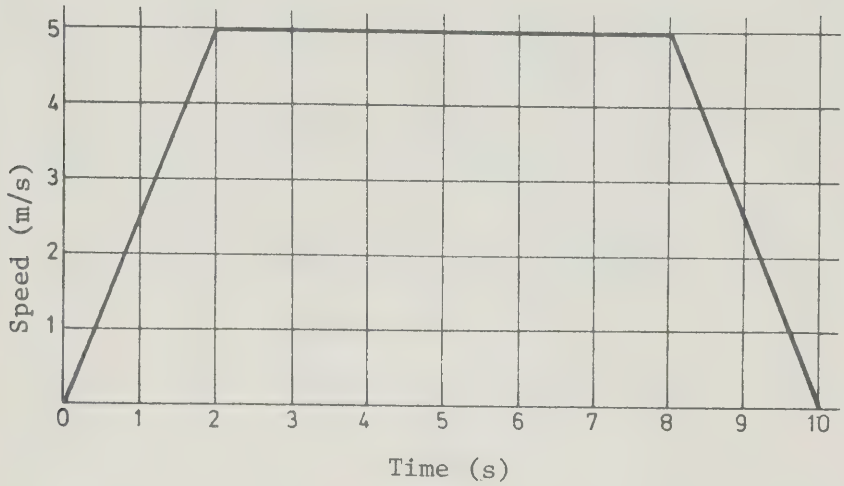
F1
A11

(B)

-

**

An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and the elevator moves as shown in the speed-time graph below.



The kinetic energy of the elevator plus its contents as it passes the <u>fifth</u> floor is

(A) 125 000 J

(B) 12 500 J

(C) 1 250 J

(D) 125 J

(E) 0 J

27 Carts P and Q have a head-on elastic collision. Their speed-time graphs are shown below.

S17C
III.5.b

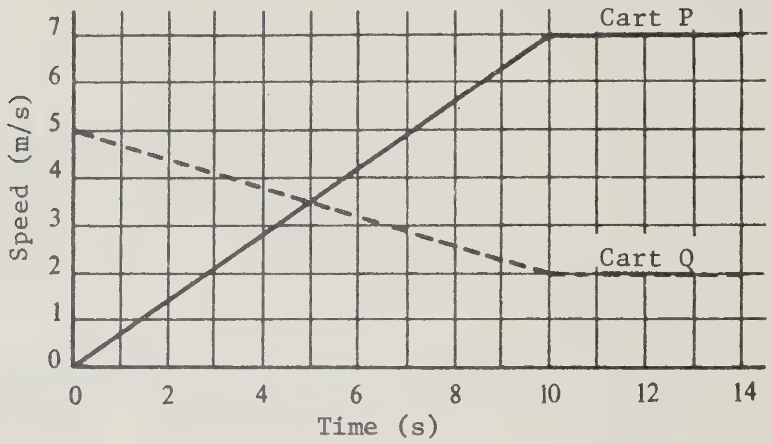
53

F1
A8
A11

(D)

\-

***



The kinetic energy of cart Q at $t = 0$ equals

(A) that of cart P at $t = 7$ s

(B) that of cart P at $t = 10$ s

(C) the sum of the kinetic energies of carts P and Q at $t = 5$ s

(D) the sum of the kinetic energies of carts P and Q at $t = 10$ s

(E) the sum of the kinetic energies of carts P and Q at all instants during the collision

28

S17C
III.5.b
S17C
III.4.a

53

A8

(C)

\-

***

A metal block is pulled in a straight line across a uniformly rough table top by a constant external force. In the first trial the speed of the block changes from 10 cm/s to 60 cm/s in 5 s. In the second trial the external force is doubled and the same speed change occurs in 2 s.

Consider: I. Gain in momentum

II. Gain in kinetic energy

III. Unbalanced force

Which of the above quantities is/are the same in the second trial as in the first?

(A) I only

(B) II only

(C) I and II only

(D) II and III only

(E) I and III only

29

S17C
III.2.c
S17C
III.5.b

53
38

F1
A8

(A)

\-

***

An object is constrained by a cord to move in a circular path of radius 0.5 m on a horizontal frictionless surface. Assuming that the cord will break if the tension in it exceeds 16 N, the maximum kinetic energy of the object is

(A) 4 J

(B) 8 J

(C) 16 J

(D) 32 J

(E) 64 J

30

S17C
III.5.b
54
F1
A8
(C)
-
***

Using a constant-frequency stroboscope, a photograph is taken of an inelastic collision between a puck and a fixed barrier. The spacing between images of the puck before the collision is 1 cm. The spacing between images after the collision is 0.8 cm. What is the ratio of the final kinetic energy of the puck to its original kinetic energy?

(A) 0.20

(B) 0.36

(C) 0.64

(D) 0.80

(E) The ratio cannot be calculated without additional information.

31

S17C
III.5.d
54
A8
(E)
-
**

Whenever a body strikes a stationary body of equal mass

(A) the two bodies cannot stick together

(B) the collision must be elastic

(C) the body that was originally moving must stop

(D) momentum is not necessarily conserved

(E) total energy of all kinds is conserved

32

S17C
III.5.c
S17C
III.1.d

54
35

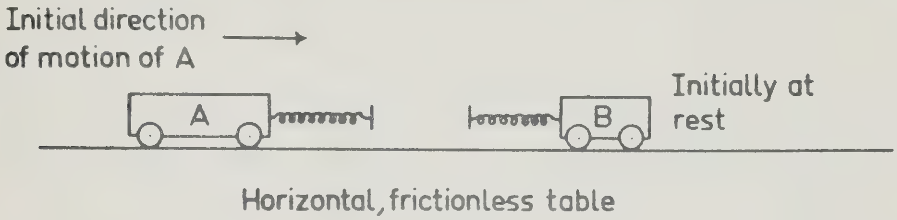
F1
A8

(A)

-

**

Two carts, A and B, having spring bumpers, undergo an elastic collision. Cart A has a mass of 75 kg and is initially moving to the right with a speed of 6.0 m/s. Cart B is initially at rest and its mass is not known. Consider all motion to the right as being positive, and assume that during the collision interval the two carts exert a constant repulsion of 150 N on each other.



During the collision, the acceleration of cart A is

(A) $-2.0\ m/s^2$

(B) $+2.0\ m/s^2$

(C) $-0.5\ m/s^2$

(D) $+0.5\ m/s^2$

(E) $-4.0\ m/s^2$

33

S17C
III.5.d

54

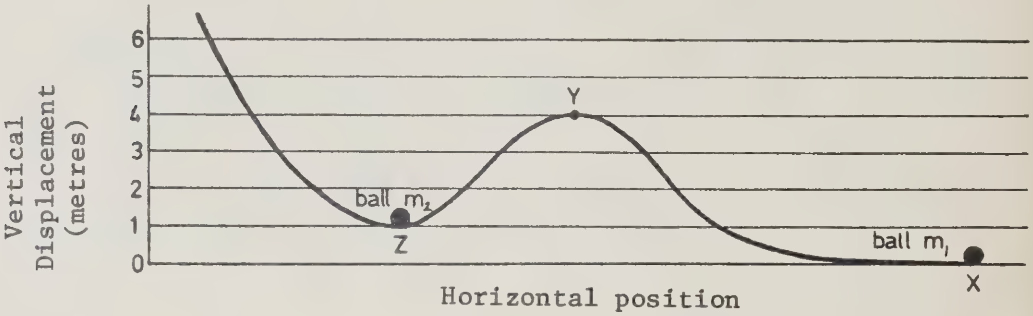
F1
A8

(D)

-

***

A steel ball m_1 of mass 1.0 kg is free to travel along a frictionless track whose course is shown in the diagram below. At time t = 0, ball m_1 passes point X with a velocity of 10 m/s to the left. When it reaches point Z, it makes an elastic collision with a second steel ball m_2, which also has a mass of 1.0 kg and is initially at rest.



During the subsequent motion of the two balls

(A) both balls eventually come to rest at point Z

(B) the balls continue indefinitely to make elastic collisions at or near point Z

(C) mass m_2 stops at point Z and mass m_1 rolls back through point X with a speed less than 10 m/s

(D) mass m_2 stops at point Z and mass m_1 rolls back through point X with a speed of 10 m/s

(E) mass m_2 continues to oscillate indefinitely about point Z and mass m_1 rolls back through point X with a speed less than 10 m/s

34

S17C
III.5.c

54

A8

(B)

-

**

Which one of the following would describe a perfectly elastic collision between two bodies?

(A) Momentum is transferred from one body to another, but no kinetic energy is transferred from one body to another.

(B) Total kinetic energy is the same after the collision as before, and total momentum is the same after the collision as before.

(C) Total kinetic energy is the same after the collision as before, but total momentum is not the same after the collision as before.

(D) Total kinetic energy is not the same after the collision as before, but total momentum is the same after the collision as before.

(E) Total momentum is the same after the collision as before, and there is no deformation of either body during the collision.

35

S17C
III.5.c

54

A1

(E)

-

**

Car A of mass 2 kg approaches and collides with car B which has a mass of 3 kg and is initially at rest.

When the separation between the cars has reached a minimum, then

(A) car B is still at rest

(B) car A has come to rest

(C) both cars have the same kinetic energy

(D) both cars have the same momentum

(E) the kinetic energy of the system has reached a minimum

36 Three cars are on a straight frictionless track. Cars X and Z each have mass m, Y has mass $2m$. Initially, Y and Z are at rest and X moves toward them with speed v. Car X collides elastically with Y, which then collides elastically with Z.

S17C
III.5.d

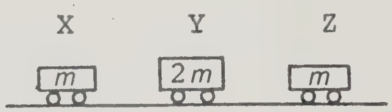
54

F1
A8
A2

(E)

-

***



After the collisions, which one of the following statements is true?

(A) X and Y are at rest; Z moves to the right with speed v.

(B) X is at rest; Y and Z move to the right.

(C) Y is at rest; X and Z each move away from Y.

(D) X and Y move to the left; Z moves to the right.

(E) X moves to the left; Y and Z move to the right.

GRAVITATIONAL

POTENTIAL ENERGY

1 Two masses $m = 2$ kg and $M = 3$ kg are joined by a cord which passes over a smooth support. The system is initially held at rest and then released. Take $g = 10$ m/s^2, neglect friction and the weight of the cord.

S17C
III.6.c

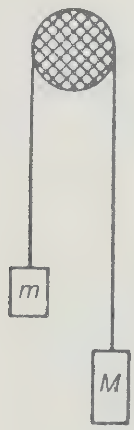
55

F1
A8

(C)

-

***



The change in the potential energy <u>of the system</u> when the mass M is displaced through 0.6 m is

(A) 0.6 J

(B) 3 J

(C) 6 J

(D) 18 J

(E) 30 J

2

S17A
I.3.d
S17C
III.6.c

55

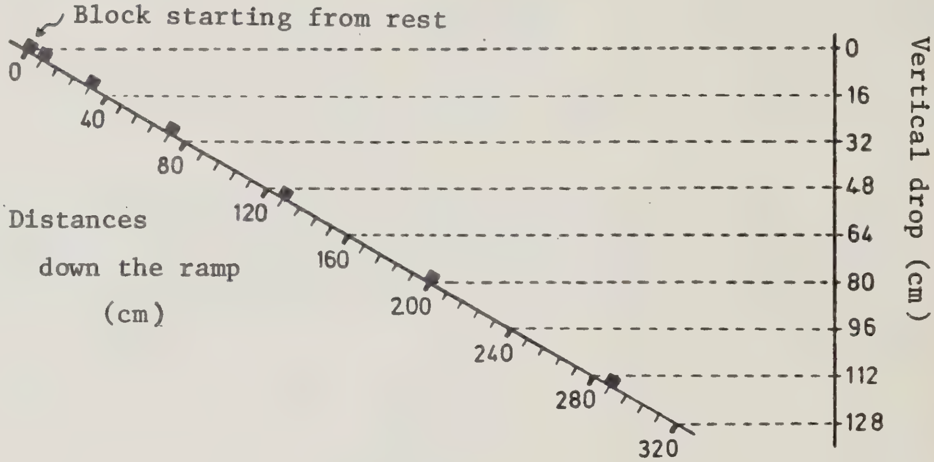
D3
F1

(A)

-

***

The multiflash picture below was taken of a 2 kg block sliding with uniform acceleration down a frictionless ramp. The multiflash operated at a rate of five flashes per second (g = 10 m/s^2)



The average rate at which the 2 kg block lost gravitational potential energy in moving down the ramp from its initial position to the 200 cm mark is about

(A) 16 W

(B) 16 J

(C) 8 W

(D) 1.6 J

(E) 1.6 W

3

S17C
III.6.f

S 55
56

A11
A8

(D)

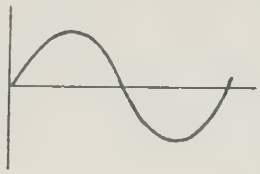
-

***

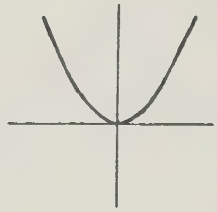
The following graphs refer to the up and down motion of a small mass hung on a vertical coil spring. Which graph best represents the total energy of the small mass and spring if the mass is released and allowed to oscillate?

(A)

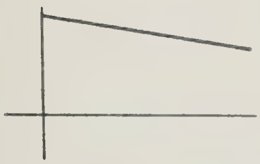
(B)



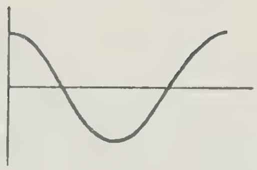
(C)



(D)



(E)



4

S17A
I.3.b
S17C
III.6.c

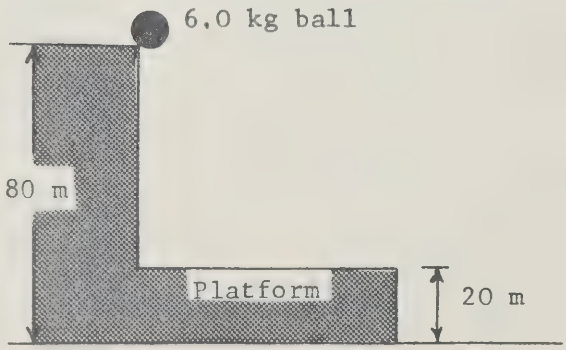
55

A3
A8
F1

(D)

**
**

In the situation illustrated, the gravitational potential energy of the ball relative to the platform is



(A) 3.6×10^2 J

(B) 4.8×10^2 J

(C) 1.2×10^3 J

(D) 3.6×10^3 J

(E) 4.8×10^3 J

5

S17A
I.3.b
S17C
III.6.c

55

F1
A8

(C)

-
***

A mass of 2 kg is hurled upward from a point situated 20 m above the earth's surface. What will be the height of the mass above the earth's surface when its gravitational potential energy has increased by 500 J? (Assume $g = 10\ m/s^2$)

(A) 5 m

(B) 25 m

(C) 45 m

(D) 70 m

(E) 270 m

6

S17A
I.3.c
S17C
III.6.f

55
56

F1
A8

(B)

***
**

A 6.0 kg mass is released from rest at a height of 80 m. If air resistance is negligible, its kinetic energy when it has fallen 60 m is

(A) 4.8×10^3 J

(B) 3.6×10^3 J

(C) 1.2×10^3 J

(D) 1.2×10^2 J

(E) zero

7

S17A
I.3.c
S17C
III.6.f

56
55

F1
A8

(D)

***
***

Locations X and Y indicate the highest and lowest positions of the bob of a simple pendulum which has a mass of 2.0 kg. If the mass is released at X, its speed at Y will be

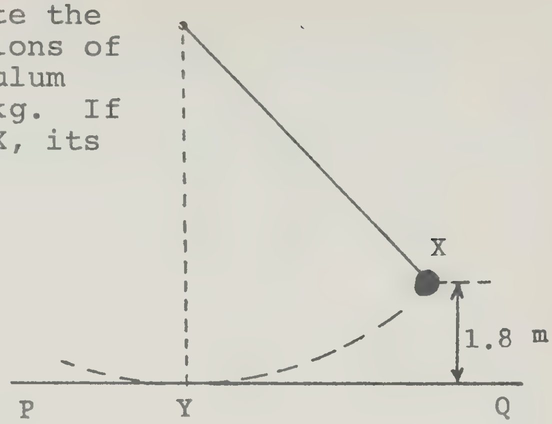
(A) 0.90 m/s

(B) $\sqrt{3.6}$ m/s

(C) 3.6 m/s

(D) 6.0 m/s

(E) 36 m/s



8

S17C
III.6.f

56

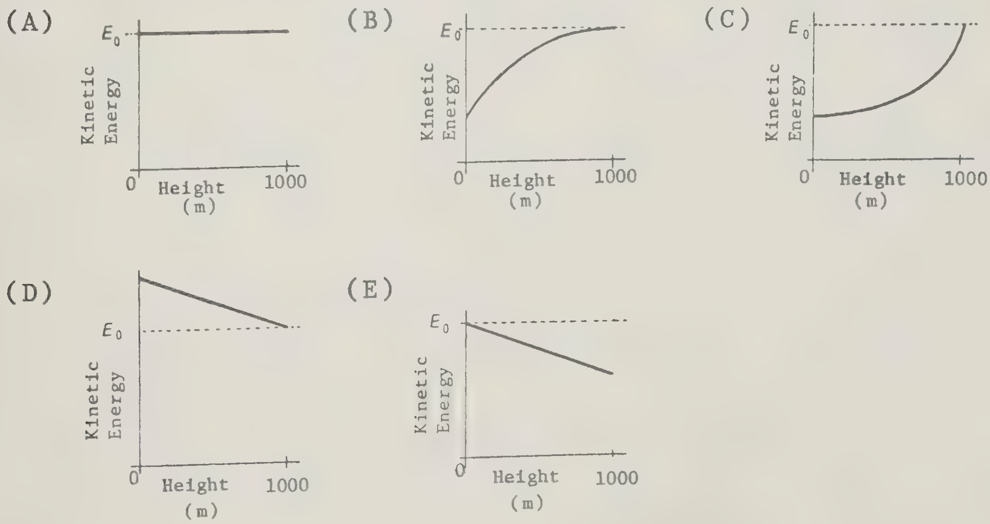
F1
A11
A8

(D)

\-

***

An aircraft, flying horizontally at an altitude of 1000 m above a level plain, releases a bomb. The kinetic energy of the bomb at the instant of release is taken as E_0. Neglecting air friction, which of the following graphs correctly illustrates the relationship between the bomb's kinetic energy and its height above the plain?



9 An elevator in an office building is rising at a constant velocity. Consider these statements concerning the elevator.

S17A
I.3.c
S17C
III.6.f
S 56
A3
(E)
-
***

I. The upward force in the supporting cable is of constant magnitude.

II. The kinetic energy of the elevator is constant.

III. Its gravitational potential energy is constant.

IV. Its acceleration is zero.

V. The sum of its kinetic energy and its gravitational potential energy is constant.

Which one of the following groups contains true statements only?

(A) I, II, III, IV, and V

(B) II and V only

(C) IV and V only

(D) I, II, and III only

(E) I, II and IV only

10

S17A
I.3.c
S17C
III.6.f

S 56

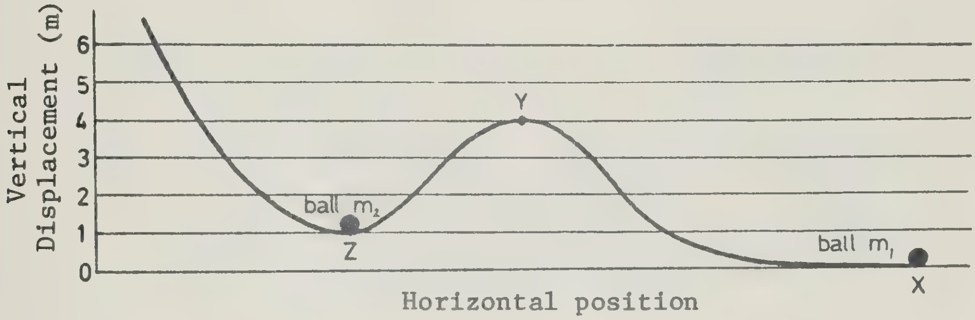
F1
A8

(A)

\-

***

A steel ball m_1 of mass 1.0 kg is free to travel along a frictionless track, whose course is shown in the diagram below. At time $t = 0$, ball m_1 passes point X with a velocity of 10 m/s to the left. When it reaches point Z, it makes an elastic collision with a second steel ball m_2, which also has a mass of 1.0 kg and is initially at rest.



The kinetic energy of ball m_1 when it reaches point Y on the track is approximately

(A) 10 J

(B) 46 J

(C) 60 J

(D) 90 J

(E) 96 J

11

S17C
III.6.b

56

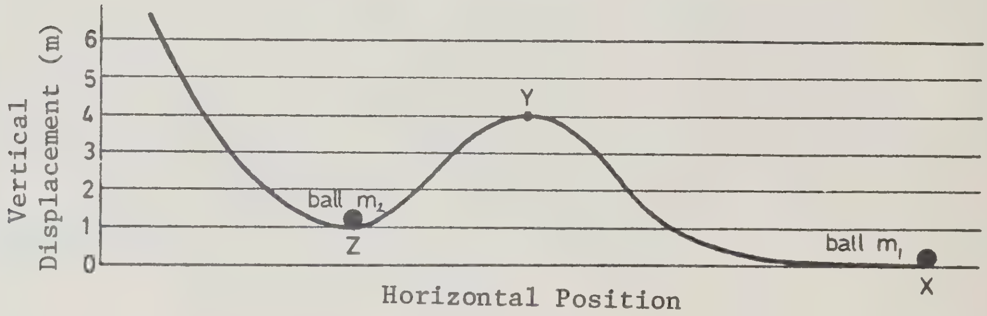
F1
A8

(A)

\-

***

A steel ball m_1 of mass 1.0 kg is free to travel along a frictionless track, whose course is shown in the diagram below. At time $t = 0$, ball m_1 passes point X with a velocity of 10 m/s to the left. When it reaches point Z, it makes an elastic collision with a second steel ball m_2, which also has a mass of 1.0 kg and is initially at rest.



After the initial collision, ball m_2 reaches a maximum vertical displacement of

(A) 5.0 m

(B) 6.0 m

(C) 9.0 m

(D) 46.0 m

(E) 50.0 m

12

S17A
I.3.c
S17C
III.6.f

S 56

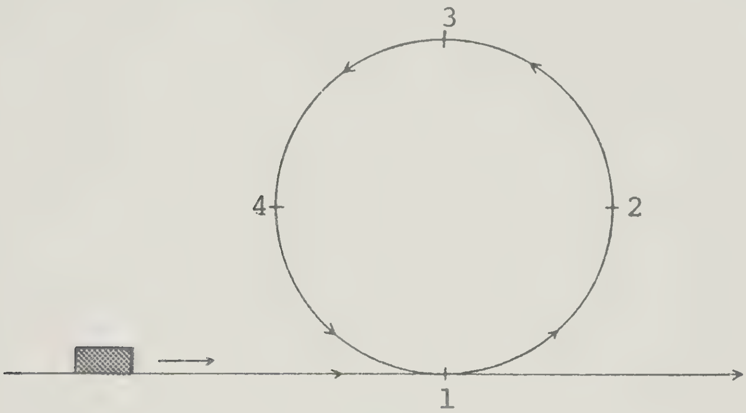
F1
A8

(D)

-

**

A rectangular block of metal is moving at constant speed along a frictionless track when it encounters a vertical circular loop and is forced to pass through points 1, 2, 3 and 4, and 1 before returning to its path on the horizontal.



Which one of the following statements is true at the instant when the block is at point 3?

(A) Its total energy is at a minimum.

(B) The forces acting on the block are balanced.

(C) The block is not accelerated.

(D) The speed of the block is at a minimum.

(E) There is an upward force on the block.

13

S17A
I.3.c
S17C
III.6.f

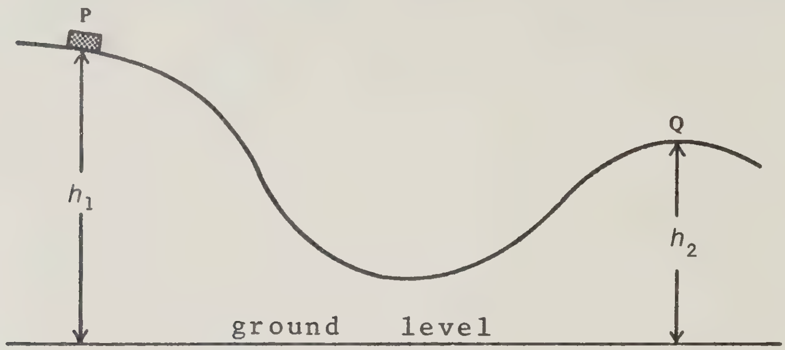
56

A8
F1
A11

(D)

–
***

An object at P originally at rest is released so that it moves down the slide.



Neglecting friction, which one of the following is the best expression for the speed of the object as it passes through point Q?

(A) $2g\sqrt{h_1 - h_2}$

(B) $2g(h_1 - h_2)$

(C) $\dfrac{h_1 - h_2}{2g}$

(D) $\sqrt{2g(h_1 - h_2)}$

(E) $\dfrac{(h_1 - h_2)^2}{2g}$

14

S17C
III.6.b

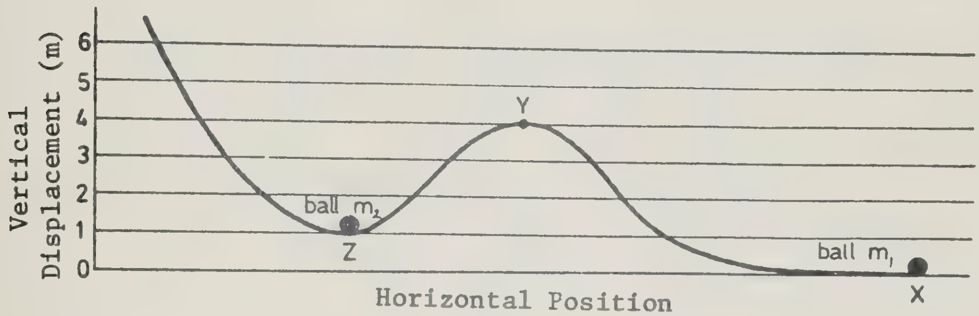
56
55
54

F1
A8

(E)

\-
**

A steel ball m_1 of mass 1.0 kg is free to travel along a frictionless track whose course is shown in the diagram below. At time $t = 0$, ball m_1 passes point X with a velocity of 10 m/s to the left. When it reaches point Z, it makes an elastic collision with a second steel ball m_2, which also has a mass of 1.0 kg and is initially at rest.



The velocity of ball m_1 immediately after it strikes ball m_2 is approximately

(A) $\sqrt{80}$ m/s to the right

(B) $\sqrt{80}$ m/s to the left

(C) $\frac{1}{2}\sqrt{80}$ m/s to the right

(D) $\frac{1}{2}\sqrt{80}$ m/s to the left

(E) zero

15 A rubber ball is held motionless above a hard floor and released. Assuming that the collision with the floor is elastic, which one of the following graphs best shows the relationship between the total energy of the ball and its height above the surface?

S17C
III.6.b

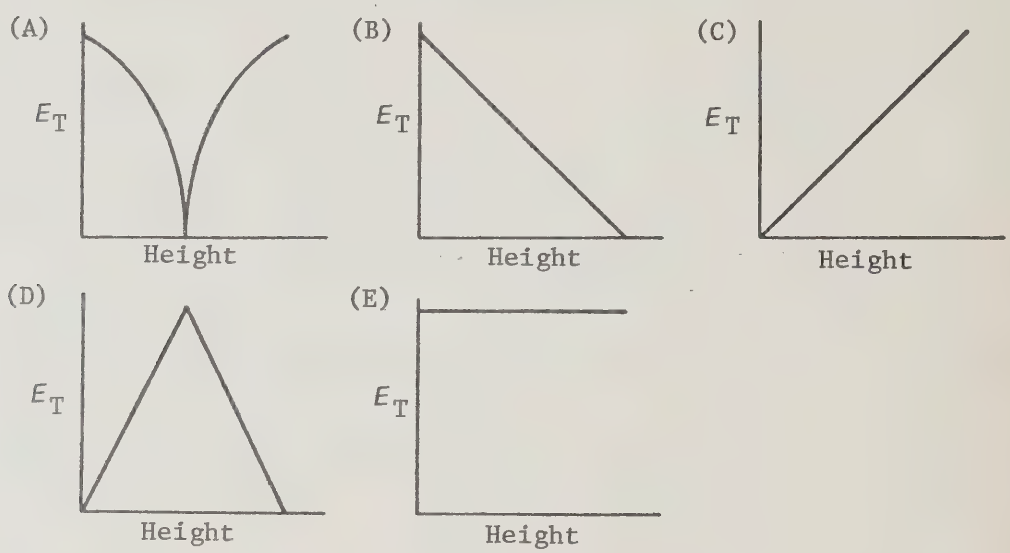
56

A11
A8

(E)

-

**



16

S17C
III.6.f

56

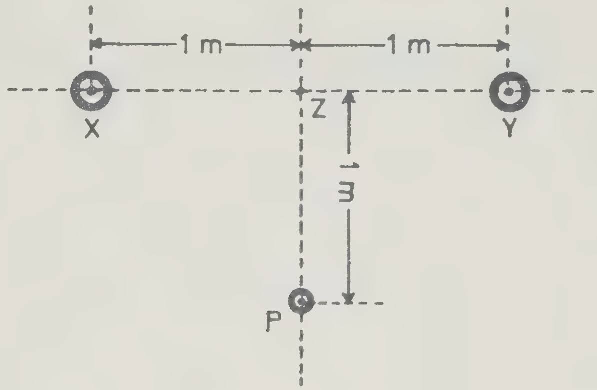
A8

(E)

-

***

Two metal spheres, each of mass 5 kg, are fixed in position at points X and Y, as shown in the diagram below. A third sphere of mass 0.01 kg is released from rest at point P and is affected only by the forces of gravitational attraction exerted on it by the masses at points X and Y. Point Z is located exactly midway between points X and Y.



After the smaller mass is released from point P, the mass will

(A) eventually come to rest at point Z

(B) move in a curved path

(C) continue to move in a straight line and come to rest permanently at a point 1 m beyond Z

(D) continue to move indefinitely in a straight line in the same direction

(E) move back and forth through point Z, returning each cycle to point P

17 It takes approximately 4×10^3 J to raise the temperature of 1 kg of water by 1°C. The gravitational field strength is approximately 10 N/kg.

S17A
I.3.c
S17C
III.6.f

56

F1
A8

(E)

\-

***

A 1 kg water "bomb" is dropped from such a height that the temperature rise of the water is 1°C when the "bomb" hits the ground.

Assume that air resistance can be neglected.

What is the approximate kinetic energy of the "bomb" just before it hits the ground?

(A) 2.5 J

(B) 4 J

(C) 10^3 J

(D) 2.5×10^3 J

(E) 4×10^3 J

18 It takes approximately 4×10^3 J to raise the temperature of 1 kg of water by 1°C. The gravitational field strength is approximately 10 N/kg.

S17A
I.3.c
S17C
III.6.f

56

F1
A8

(B)

\-

***

A 1 kg water "bomb" is dropped from such a height that the temperature rise of the water is 1°C when the "bomb" hits the ground.

Assume that air resistance can be neglected.

From what approximate height is the "bomb" dropped?

(A) 2.5×10^{-3} m

(B) 4×10^2 m

(C) 2.5×10^3 m

(D) 4×10^3 m

(E) 4×10^4 m

19

S17C
III.6.e

S 57

F1
A8

(C)

\-

***

If we let m represent the mass of a rocket,
M the mass of the earth,
R the radius of the earth,
and G the universal gravitational constant,
then the velocity required for the rocket to escape from the earth's gravitational field is equal to

(A) $\sqrt{\frac{2GMm}{R}}$

(B) $\frac{GMm}{R^2}$

(C) $\sqrt{\frac{2GM}{R}}$

(D) $\frac{GMm}{R}$

(E) $\frac{\sqrt{GM}}{R}$

20

S17C
III.6.d

57

F1
A8

(B)

\-

***

A mass m is at a distance r from a second mass M. The gravitational potential <u>energy</u> of mass m with respect to mass M is multiplied by a factor of 4 if

(A) r is halved

(B) r is halved and M is doubled

(C) r^2 is halved

(D) r^2 is halved and m is doubled

(E) r is doubled and M is doubled

21		An earth satellite is in a stable circular orbit. A booster rocket puts it in another circular orbit of somewhat larger radius. Which one of the following statements is <u>false</u>?
S17C III.6.e		
S 57	(A)	The period of the satellite is increased.
F1 A8	(B)	The gravitational attraction experienced by the satellite is decreased.
(C)	(C)	The kinetic energy of the satellite is decreased.
- ***	(D)	The gravitational potential energy of the satellite is increased.
	(E)	The orbital speed of the satellite is increased.

BEHAVIOURS OF LIGHT

AND

MODELS OF LIGHT

GEOMETRIC OPTICS

1 A light beneath the surface of the water in a tank is located as shown in the diagram. An electronic sensor that can determine the speed of light as well as the intensity of illumination is moved from X to Y along the bottom of the tank.

S17A
II.3.a
S17C
II.1.a

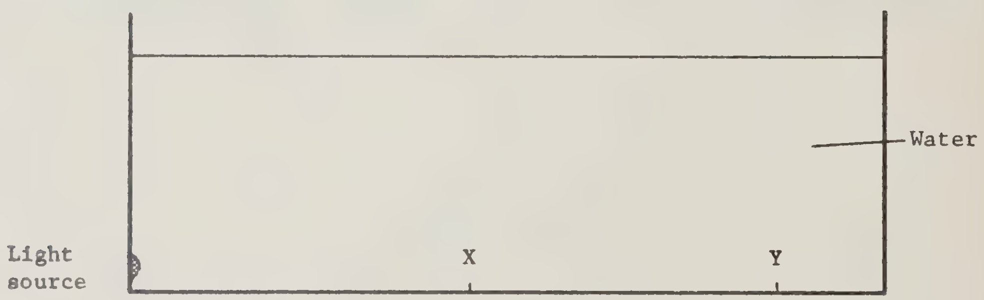
58
67

A1
A8

(B)

-

***



Which of the following observations would you expect to make as the sensor moves from X to Y?

(A) The speed and intensity of the light remain unchanged.

(B) The speed remains the same but the intensity decreases.

(C) Both the speed and the intensity decrease.

(D) The intensity decreases but the speed increases.

(E) The intensity remains the same but the speed decreases.

2

S17C
II.1.a
S17C
I.3.c

S 58
S 16

F1
A1

(C)

***
*

A stone falls freely toward a plane horizontal mirror. The stone's image accelerates

(A) relative to the stone at 10 m/s^2 upward

(B) relative to the stone at 5 m/s^2 upward

(C) relative to the stone at 20 m/s^2 upward

(D) relative to the mirror at 20 m/s^2 upward

(E) relative to the mirror at 10 m/s^2 downward

3

S17A
II.3.a
S17C
II.2.f

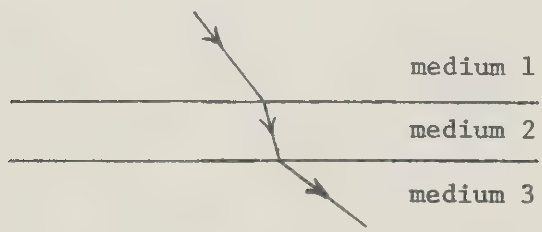
60

D3
A8

(C)

***
**

A narrow pencil of light is transmitted through different media as shown in the diagram.



If v represents the speed of light, then

(A) $v_1 > v_2 > v_3$

(B) $v_3 > v_2 > v_1$

(C) $v_3 > v_1 > v_2$

(D) $v_2 > v_1 > v_3$

(E) $v_1 > v_3 > v_2$

4

Each sketch below traces the path of a ray of light passing from water into glass and then into air. The index of refraction of water is 1.3, that of glass is 1.5, and that of air is 1.0. Select the sketch which best represents the path of the ray.

S17A
II.3.a
S17C
II.1.b

60

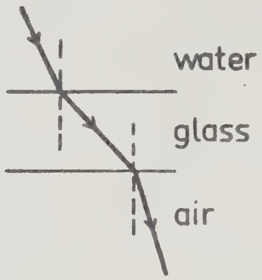
F1
B1
A8
A2

(E)

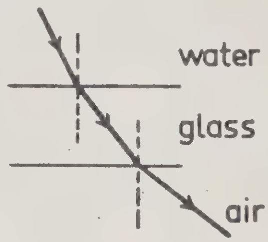
\-

**

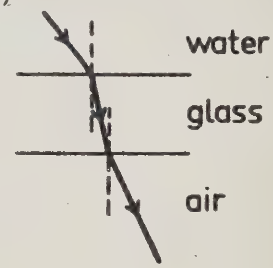
(A)



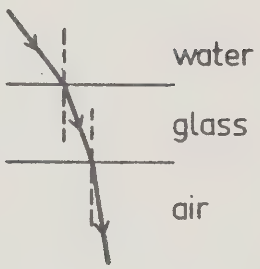
(B)



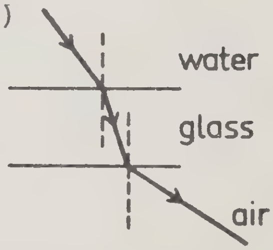
(C)



(D)



(E)



5

S17A
II.3.a
S17C
II.1.b

60

A8
F1

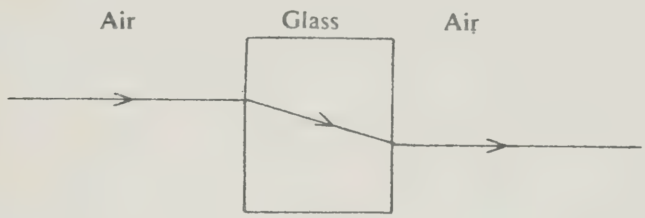
(D)

\-

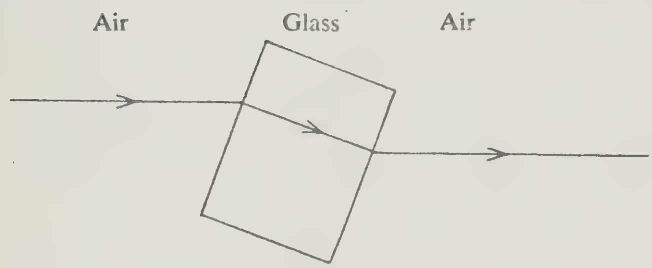
***

Which drawing best represents the correct passage of a ray of light through a rectangular block of glass?

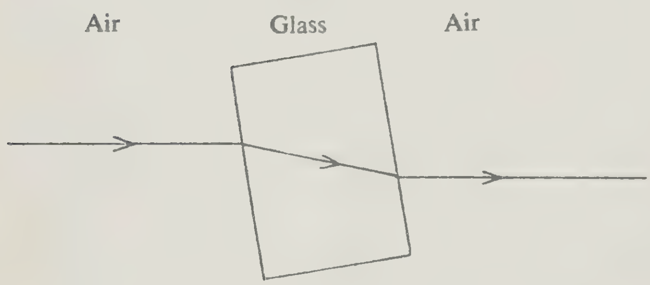
(A)



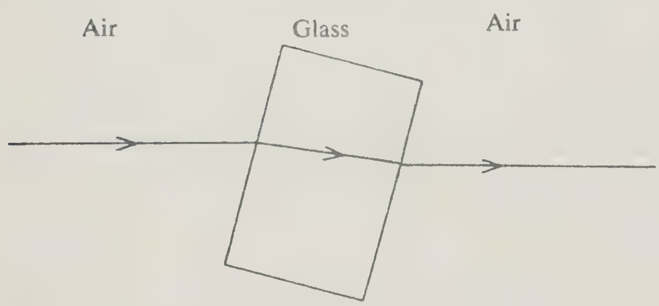
(B)



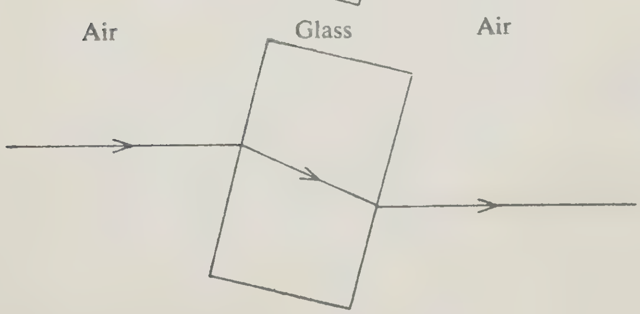
(C)



(D)



(E)



6	When light strikes matter, one or more of the following phenomena may occur:
S17A	
II.3.a	I. reflection
S17C	
II.1.a&b	II. refraction
61	III. transmission
B1	IV. absorption
A3	
A2	Which of these phenomena occur when light strikes a plate-glass window?
(E)	
	(A) I and II only
**	
*	(B) II and III only
	(C) II, III and IV only
	(D) III only
	(E) I, II, III and IV

PARTICLE MODEL OF LIGHT

1 A group of students who are discussing the nature of light make the following statements:

S17C
II.2
63
E3
(E)
-
***

I. A particle model of light predicts rectilinear propagation, reflection, refraction, an inverse square law for the intensity from a point source, and the existence of radiation pressure.

II. A particle model of light predicts that the speed of light will decrease as light goes from water into air in contradiction to experiment.

III. The particle model of light cannot account for diffraction and interference phenomena, whereas the wave model can.

IV. With the ripple tank one studies the behaviour of water waves. Therefore it is only by analogy that one learns anything about light from ripple tank experiments.

V. Ripple tank experiments give us an appreciation of what is meant by a wave model.

Which of the above statements is/are correct?

(A) V only

(B) III and V only

(C) I, III, and V only

(D) I, III, IV, and V only

(E) They are all correct.

2

S17C
II.2

63

E2

(B)

-

**

A light beam is observed to travel in a straight line from a source A to a screen B 2.0 m away. A small sphere projected from A toward B at a speed of 20 m/s follows a parabolic path and strikes the screen below B. If we are to adopt a particle model for light, then <u>on the basis of these observations only</u> it must be concluded that

(A) the particles have very small mass

(B) the particles are travelling very much faster than 20 m/s

(C) the particles have very small momentum

(D) the particles have a very large energy compared to that of the sphere

(E) a particle model is unsatisfactory

3

S17C
II.2

63

E3

(A)

-

***

The particle model of light requires some or all of the following assumptions:

I. The particles are small in size compared to the spacing between them.

II. The particles have very small mass.

III. The particles are travelling very quickly.

A beam of red light is observed to pass through a beam of blue light. In order to explain this observation, which of the above assumptions is/are required?

(A) I only

(B) III only

(C) I and II only

(D) I and III only

(E) I, II and III

4

S17C
II.2.e

65

E3
All

(E)

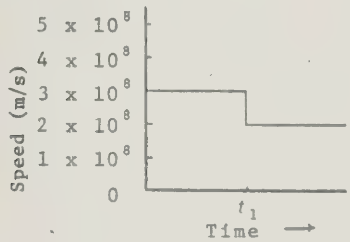
\-

***

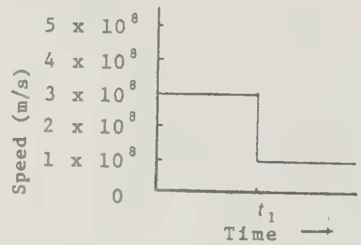
On the basis of the <u>particle model</u> for light, which of the following is the most suitable speed-time graph to describe the <u>predicted</u> behavior of a "particle" of light when passing from GLASS to AIR?

NOTE: The index of refraction of glass is 1.5 and t_1 is the instant when the particle crosses the glass-air boundary. The speed of light in air is 3×10^8 m/s.

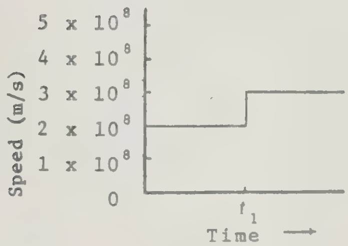
(A)



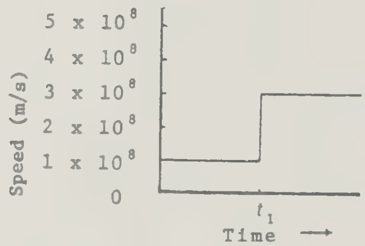
(B)



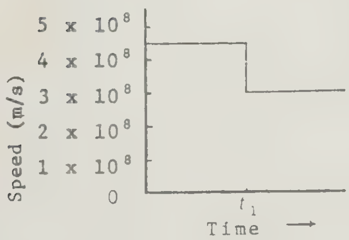
(C)



(D)



(E)



5

S17C
II.2.e

65

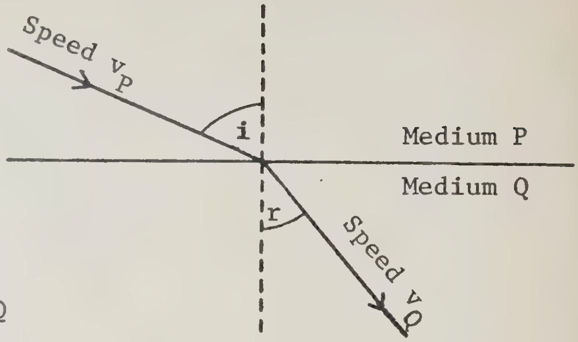
E3
A1
A8

(B)

-

***

A ray of light travels from medium P into medium Q, and is refracted toward the normal.



Consider the following statements:

I. $\sin i/\sin r = v_P/v_Q$

II. $\sin i/\sin r = v_Q/v_P$

III. $v_P > v_Q$

IV. $v_Q > v_P$

Which combination of the above statements is true according to the particle model?

(A) I and III only

(B) II and IV only

(C) I and IV only

(D) II and III only

(E) None of these.

6

S17C
II.2.e

67

A8
F1

(A)

-

***

A small radioactive source emits beta particles uniformly in all directions such that the average number passing through a small opening at a distance of 10 cm from the source is 180/s. If the source were moved a further 20 cm from the opening, the number of beta particles passing through the opening each second would be

(A) 20

(B) 45

(C) 60

(D) 90

(E) 180

7

S17C
II.2.e

67

F1

(B)

-

***

Two identical lamps, X and Y, are located at the centres of two hollow spheres. The sphere around X has a radius of 300 cm and the sphere around Y has a radius of 200 cm. For a fixed time interval, what is the ratio of the total amount of light striking sphere X to the total amount of light striking sphere Y?

(A) 2:3

(B) 1:1

(C) 3:2

(D) 9:4

(E) 4:9

8

S17C
II.2.e

67

F1
A8

(A)

-

**

When the distance between a point light source and a light meter is reduced from 6.0 m to 3.0 m, the intensity of illumination at the meter will be equal to the original intensity multiplied by

(A) four

(B) two

(C) one-half

(D) one-quarter

(E) one-ninth

9

S17C
II.2.e

67

F1
A8

(E)

-

**

The intensity of illumination is observed to be Y units at a distance *d* from a source. What is the intensity at a distance 0.5 *d* if the power of the source is doubled?

(A) 0.5 Y

(B) Y

(C) 2Y

(D) 4Y

(E) 8Y

10 The intensity of illumination from a point source varies directly as the power of the source and inversely as the square of the distance from the source.

S17C
II.2.e

S 67

F1
A11

(E)

\-

***

Two small light sources, S_1 of 20 W and S_2 of 10 W are placed 3 m apart. A light meter is placed one metre from S_1 on the line joining S_1S_2. The light meter is turned so that it first faces S_1 and then S_2. The intensities I_1 and I_2 of light falling on the meter are measured.

The ratio of the intensities $I_1:I_2$ will be

(A) 1:4

(B) 1:2

(C) 1:1

(D) 4:1

(E) 8:1

11 A simple particle model for light can account for all of the following phenomena but one. Which one is <u>not</u> accounted for?

S17C
II.2.f

68

E3
A9

(B)

\-

***

(A) The intensity of light from a point source varying inversely as the square of the distance from the source.

(B) Color effects in thin soap films.

(C) Radiation pressure.

(D) Snell's law of refraction.

(E) The formation of multiple images by two plane mirrors.

CHARACTERISTICS AND BEHAVIOURS OF WAVES

1 Which one of the following properties of a wave decreases as the wave moves along a spring?

S17A
II.1.b
S17C
II.3.a

69

B1
A2

(A)

-

*

(A) amplitude

(B) wavelength

(C) speed

(D) frequency

(E) period

2 The diagram below shows a portion of a rope in which a disturbance XY travels in the direction of the arrow.

S17A
II.1.b
S17C
II.3.a

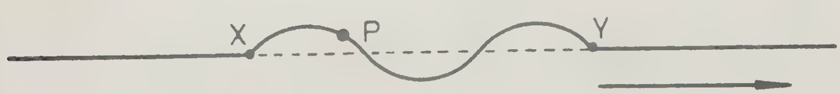
69
16

A1
A11

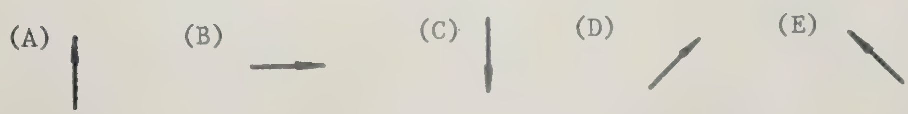
(A)

-

***



The instantaneous velocity of a particle of the rope at point P is best represented by which one of the following vectors?



3

S17A
II.1.a

69

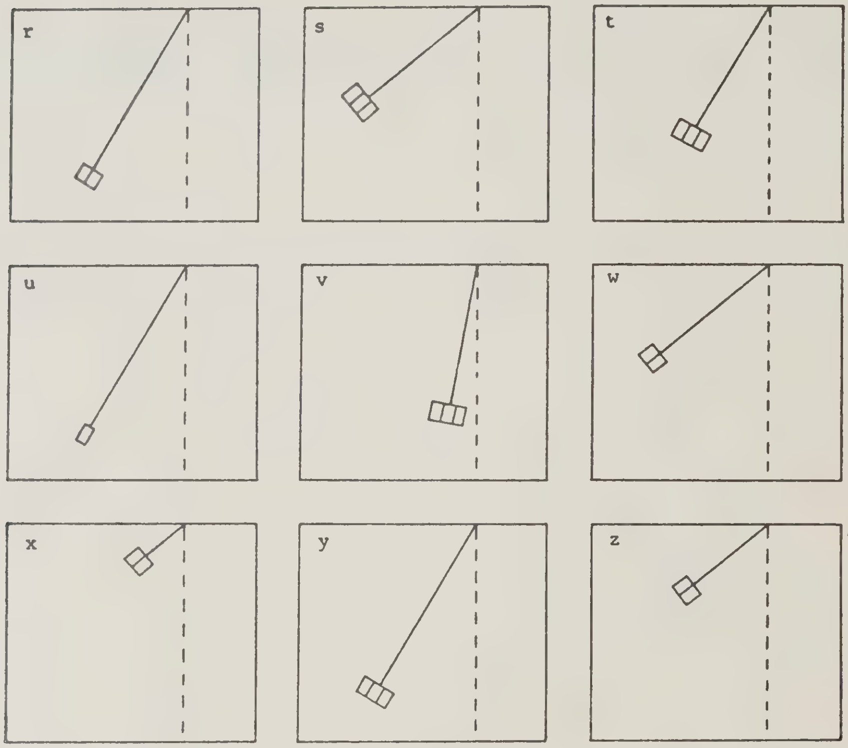
C3

(E)

–

**

The sketches below show different situations with a pendulum which is about to be released.



You want to test this idea: the more mass the bob of the pendulum has, the more time it will take to come to rest.

Which three tests would you use?

(A) s t v

(B) w x z

(C) r u z

(D) v x y

(E) r u y

4

S17A
II.1.b
S17C
II.3.a

69

F1
A2

(A)

-

***

The wavelength of a transverse wave train is 20 cm and its amplitude is 4 cm. At a point P the displacement is -4 cm. At the same instant, at point Q, 25 cm away in the direction of propagation of the wave, the displacement is

(A) 0 cm

(B) 2 cm

(C) -2 cm

(D) 4 cm

(E) -4 cm

5

S17A
II.1.c
S17C
II.4.b

70

A8
F1

(D)

-

*

A source S generates circular waves on a lake. The pattern of wave crests is shown in the diagram below.

If the frequency of the source is 2.0 Hz and the wave speed is 5.0 m/s then the distance between adjacent wave crests is

(A) 0.20 m

(B) 0.40 m

(C) 1.25 m

(D) 2.5 m

(E) 10 m

6

S17A
II.1.c
S17C
II.4.b

S 70

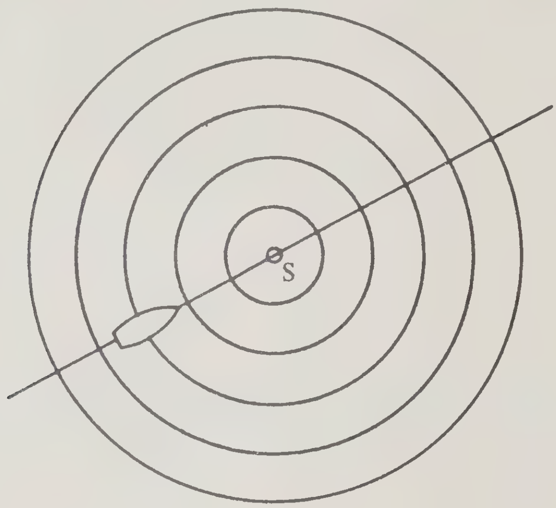
F1
A8

(D)

-

***

A source S generates circular waves on a lake. The pattern of wave crests is shown in the diagram below. The speed of the waves is 5.0 m/s, and the crest-to-crest separation is 2.0 m. A man in a motor boat heads directly toward S with a constant speed of 3.0 m/s.



To the man, the apparent frequency of the waves is

(A) 1.0 Hz

(B) 1.5 Hz

(C) 2.0 Hz

(D) 4.0 Hz

(E) 8.0 Hz

7

S17A
II.1.c
S17C
II.4.b

70

F1

(D)

-
***

A rope 2 m long is hanging vertically from a vibrator. It is noted that a single pulse travels to the end of the rope in 0.5 s. What frequency should be used in the vibrator to maintain three whole waves in the rope?

(A) $\frac{3}{4}$ Hz

(B) $\frac{4}{3}$ Hz

(C) 4 Hz

(D) 6 Hz

(E) 8 Hz

8

S17A
II.1.c
S17C
II.4.b

70

F1
A8

(E)

-

**

A wave whose speed in a spring is 4.4 m/s enters a second spring. The wavelength changes from 2.0 m to 3.0 m. The wave in the second spring travels at

(A) 1.46 m/s

(B) 2.2 m/s

(C) 2.9 m/s

(D) 4.4 m/s

(E) 6.6 m/s

9

S17A
II.1.c
S17C
II.4.b

70

A8
F1

(B)

-

**

Waves of frequency f, wavelength λ, and velocity v may be propagated in a certain medium. If the frequency is doubled, then for waves in the same medium

(A) λ is doubled and v is the same

(B) λ is halved and v is the same

(C) λ is the same and v is doubled

(D) λ is the same and v is halved

(E) λ is halved and v is doubled

10

S17C
II.4.b

70

F1
B3
A7

(C)

-

*

A vibrating source in a ripple tank produces straight waves having a frequency of 15 Hz. Using a 5-slit stroboscope to stop the motion, it is found that the distance between successive crests is 2 cm.

The speed of the waves is

(A) 6.0 cm/s

(B) 7.5 cm/s

(C) 30 cm/s

(D) 37.5 cm/s

(E) 150 cm/s

11

S17A
II.1.c
S17C
II.4.b

70

F1
A2

(D)

\-

***

What is the wavelength of radar waves of frequency 3000 MHz? The speed of light is 3×10^8 m/s.

(A) 10^5 m

(B) 10^2 m

(C) 10 m

(D) 10^{-1} m

(E) 10^{-2} m

12

S17C
II.4.c

70

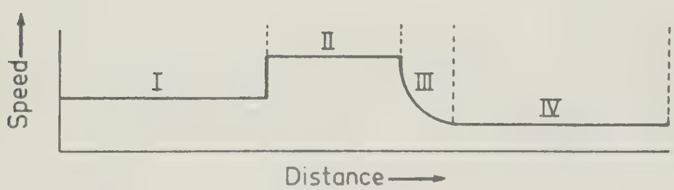
A1

(A)

\-

**

The graph below shows speed versus distance for waves generated in a water tank. Recall that the speed of water waves increases with the depth.



The frequency of the waves is

(A) the same in all sections

(B) greatest in section IV

(C) variable in section III

(D) lower in section I than in section III

(E) greatest in section II

13

S17C
II.4.c

70

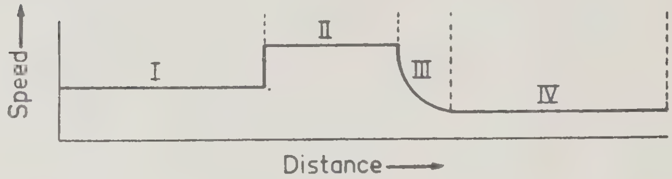
A8
A11
F1
A1

(C)

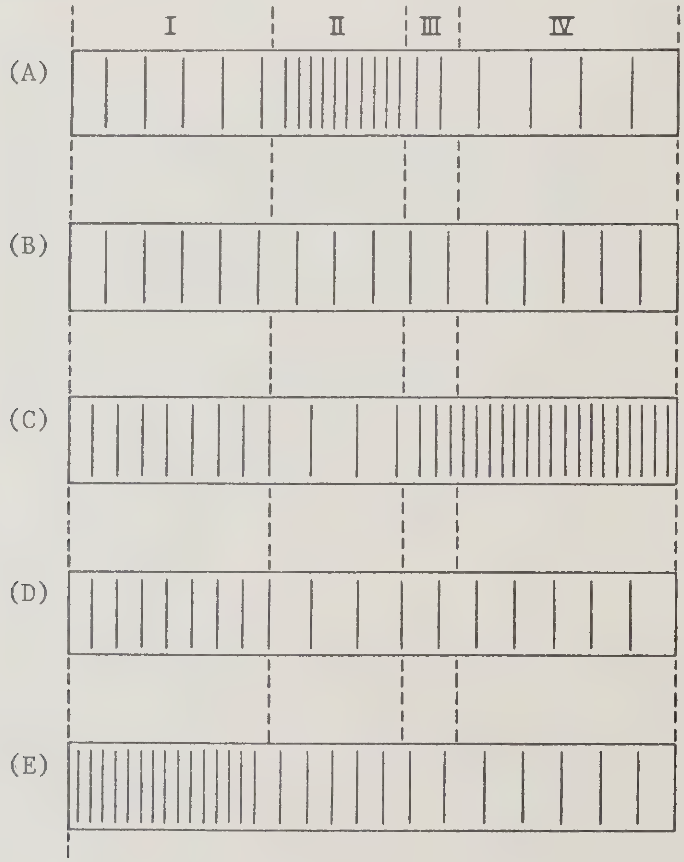
-

**

The graph below shows speed versus distance for waves generated in a water tank. Recall that the speed of water waves increases with the depth.



Assume that the walls of the tank are perfectly absorbing. Which one of the following wave patterns, as viewed from above, could result from waves generated in the tank?



14

S17C
II.4.b

S 70

F1
B3
A7

(C)

\-

*

A vibrating source in a ripple tank produces straight waves having a frequency of 15 Hz. Using a 5-slit stroboscope to stop the motion, it is found that the distance between successive crests is 2 cm.

The minimum rate of rotation required for the stroboscope to stop the wave motion is

(A) $\frac{1}{15}$ Hz

(B) $\frac{1}{3}$ Hz

(C) 3 Hz

(D) 15 Hz

(E) 75 Hz

15

S17A
II.1.c
S17C
II.4.b

70

A3
A8
F1

(E)

***
**

Water waves generated in a ripple tank are observed to have crests 5.0 cm apart. The speed of the waves is 20 cm/s. How long does it take for a new wave to be generated?

(A) 100 s

(B) 4.0 s

(C) 2.0 s

(D) 0.50 s

(E) 0.25 s

16

S17A
II.1.c
S17C
II.4.b

A narrow beam of light travels from a vacuum into a substance S at an angle of incidence of 45°. The light has a frequency of 6.00×10^{14} Hz in the vacuum and a speed of 2.13×10^{8} m/s in the substance S. (The speed of light in a vacuum is 3.00×10^{8} m/s.) The wavelength of the light in the vacuum is

70

(A) less than the wavelength in S

F1
A8

(B) $\frac{3.00}{1.41} \times 10^{-8}$ m

(C)

(C) 5.00×10^{-7} m

\-

(D) 3.55×10^{-7} m

***

(E) 5.00×10^{-5} m

17

S17A
II.1.c
S17C
II.4.b

Light travelling at a speed of 3.0×10^{8} m/s in a medium in which its wavelength is 6.0×10^{-7} m has a frequency of

(A) 2.0×10^{-15} Hz

70

(B) 1.8×10^{2} Hz

F1
A8

(C) 5.0×10^{14} Hz

(D) 2.0×10^{15} Hz

(C)

(E) 5.0×10^{15} Hz

**
*

18

S17A
II.1.b
S17C
II.4.b

Which of the following statements correctly describes the changes that occur in a sound wave when it passes from cool air into warmer air?

70
149

(A) The speed, wavelength, and frequency all increase.

(B) The speed and wavelength increase, and the frequency decreases.

F1
A1

(C) The speed and wavelength decrease, and the frequency remains constant.

(D)

(D) The speed and wavelength increase, and the frequency remains constant.

***

\-

(E) The speed and frequency increase, and the wavelength decreases.

19

S17C
II.4.a

71

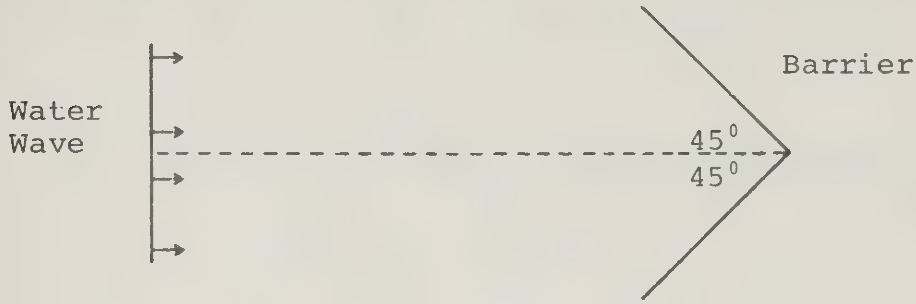
B1
A8

(E)

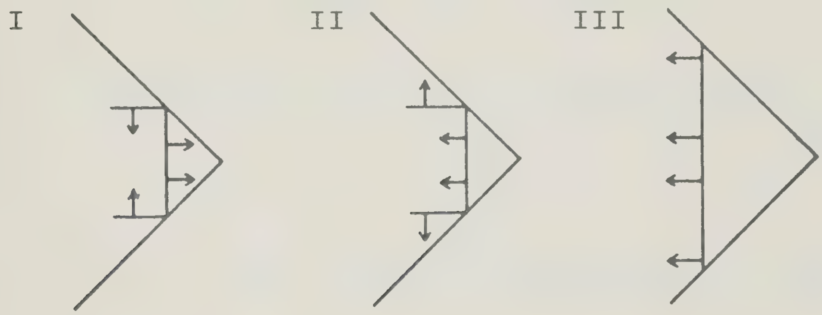
-

***

A straight water wave is sent into a barrier in a water tank as shown below.



Consider the following instantaneous patterns.



Which of the above patterns can occur?

(A) III only

(B) I and II only

(C) I and III only

(D) II and III only

(E) I, II and III

20

S17C
II.4.a

71

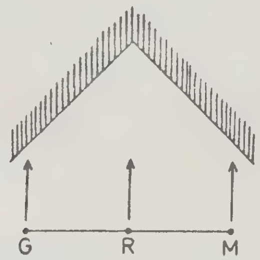
F1
D3

(D)

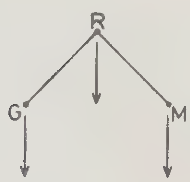
-

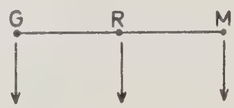
***

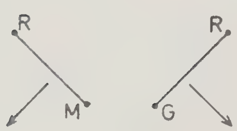
Two straight reflecting surfaces are set at right angles to each other. A straight wave front GRM approaches the surfaces in the direction of the bisector of the right angle, as shown in the diagram below.

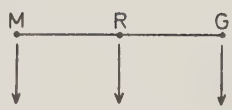


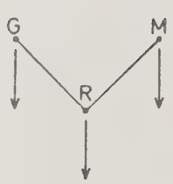
After reflection, the form of the wave front will be

(A) 

(B) 

(C) 

(D) 

(E) 

21

S17C
II.3.b

S 71

A11

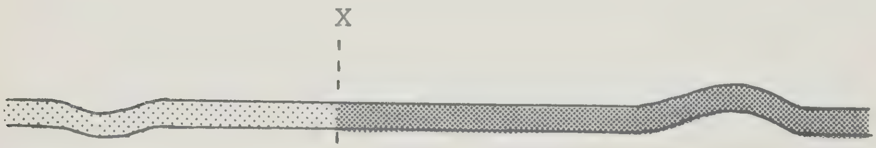
(C)

***
**

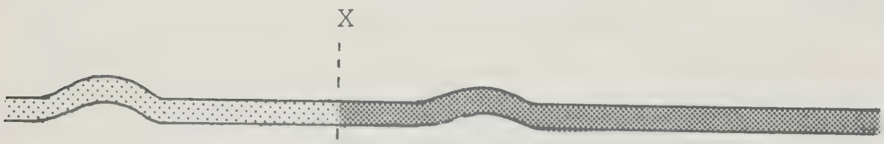
The line X represents the boundary between two dissimilar springs. A pulse is shown approaching the boundary.

Which one of the following sketches shows a possible configuration of the system shortly after the pulse reaches the boundary?

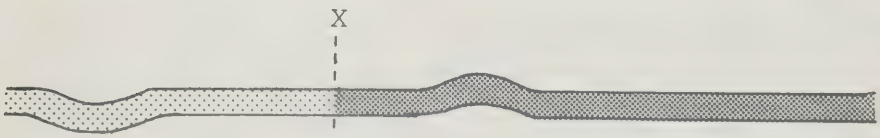
(A)



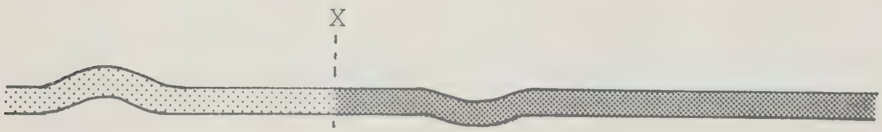
(B)



(C)



(D)



(E)

22

S17C
II.4.c

72

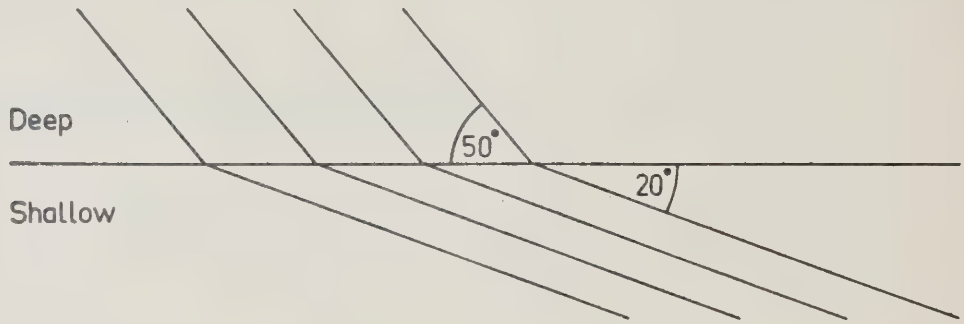
A2

(B)

–

***

The diagram below illustrates a series of wave fronts travelling from a shallow to a deep portion of a tank of water.



The angle of refraction in this case is

(A) 70^0

(B) 50^0

(C) 40^0

(D) 30^0

(E) 20^0

23

S17C
II.4.c

72

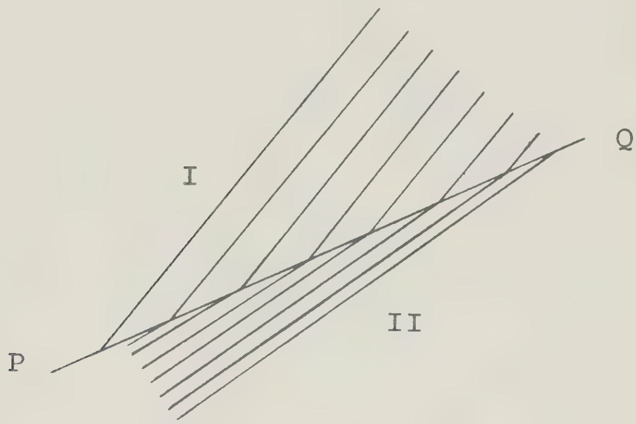
D3
B1

(E)

-

**

PQ represents the boundary between regions I and II, having different depths, in a ripple tank containing water. Wave fronts are shown crossing the boundary.



Which statement best describes the situation?

(A) I is a shallow region, II is a deeper region, and the waves are travelling from I to II.

(B) I is a deep region, II is a more shallow region, and the waves are travelling from I to II.

(C) I is a deep region, II is a more shallow region, and the waves are travelling from II to I.

(D) Both statements (A) and (C) are possible.

(E) Both statements (B) and (C) are possible.

24

S17C
II.4.c

72

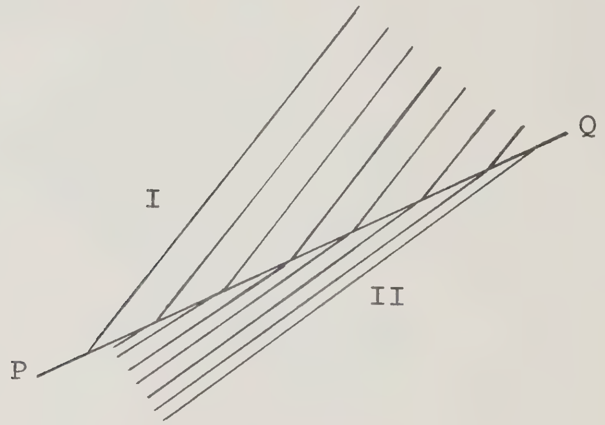
D3
B1

(A)

-

**

PQ represents the boundary between regions I and II, having different depths, in a ripple tank containing water. Wave fronts are shown crossing the boundary.



Which of the following correctly describes the waves in region II as compared to those in region I?

NOTE: v represents wave velocity
λ represents wavelength
f represents frequency
T represents period

(A) In region II, f is the same, v is less, and λ is less than in region I.

(B) In region II, f is the same, v is greater, and λ is greater than in region I.

(C) In region II, f is the same, v is greater, and λ is less than in region I.

(D) In region II, v is the same, T is less, and λ is less than in region I.

(E) In region II, v is the same, T is greater, and λ is less than in region I.

25

S17C
II.4.c

72

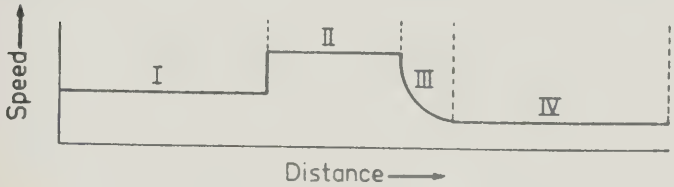
F1
A1
A11

(E)

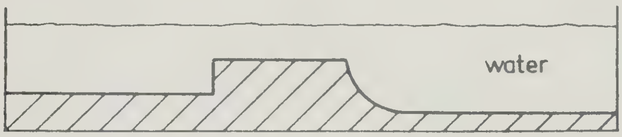
-

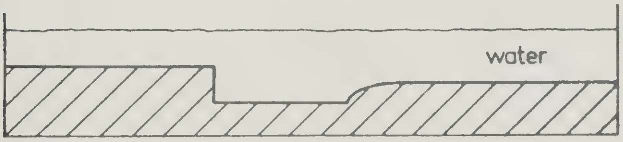
**

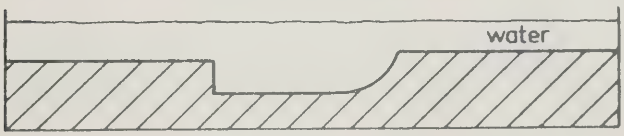
The graph below shows speed versus distance for waves generated in a water tank. Recall that the speed of water waves increases with the depth.



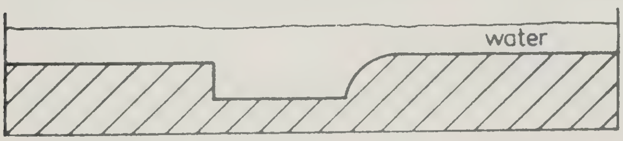
Which one of the following tanks (shown in sectional view) would account for the graph above?

(A)


(B)


(C)


(D)


(E)


26

S17C
II.4.c

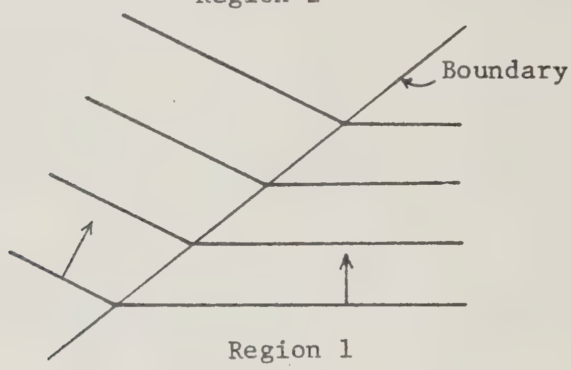
72

F1

(B)

***
***

Water waves travel from Region 1 to Region 2 as shown in the diagram.



The wavelength is 5 cm in Region 1 and 6 cm in Region 2. The corresponding speeds are v_1 and v_2.

The ratio $\frac{v_1}{v_2}$

(A) is $\frac{6}{5}$

(B) is $\frac{5}{6}$

(C) cannot be determined since the speeds are not given

(D) cannot be determined since the frequencies are not given

(E) cannot be determined since the angles of incidence and refraction are not given

27

S17C
II.4.c

72

F1
A3

(A)

**
*

In a ripple tank experiment, water waves have a wavelength of 2.0 cm and a frequency of 15 Hz. Upon entering a new region the wavelength of the waves becomes 1.6 cm. In this region the waves have

(A) a frequency of 15 Hz and a speed of 24 cm/s

(B) a frequency of 12 Hz and a speed of 24 cm/s

(C) a frequency of 15 Hz and a speed of 30 cm/s

(D) a frequency of 19 Hz and a speed of 30 cm/s

(E) a frequency of 15 Hz and a speed of 38 cm/s

28

S17C
II.4.c

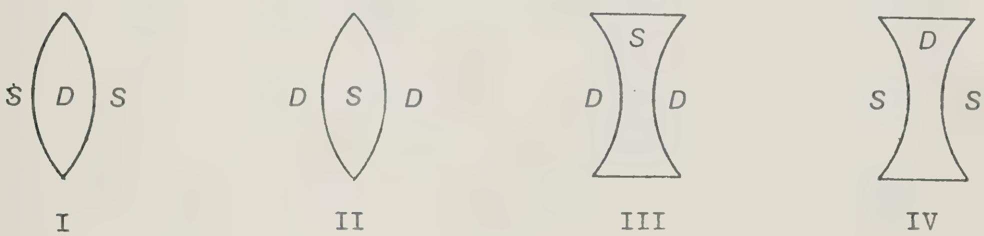
72

F1
A10

(D)

***
***

Which of the following arrangements in a ripple tank would cause parallel straight waves entering from the left to be converged? (*D* signifies deep water, *S* shallow water.)



(A) I only

(B) III only

(C) both I and III

(D) both II and IV

(E) both I and II

29

S17C
II.4.d

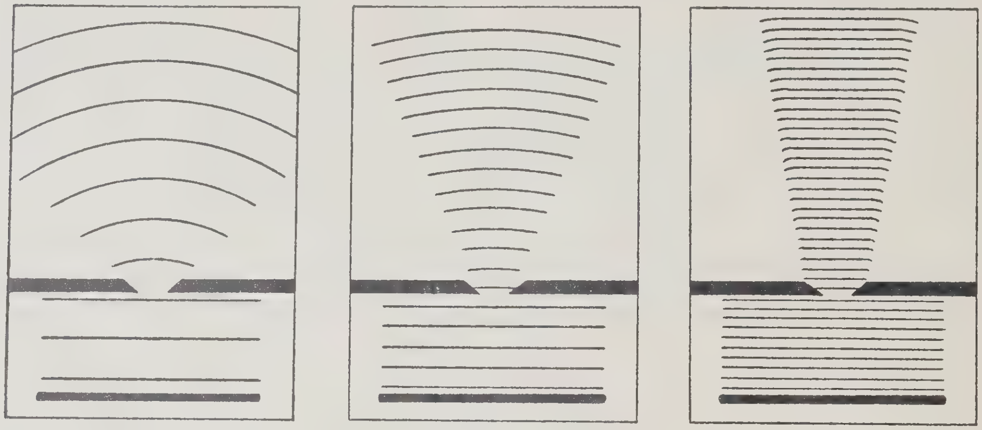
74

D3

(A)

***
***

Ripple tanks were used to perform a series of experiments on diffraction. The following diagrams represent the observations made.



Consider the following possible conclusions:

I. As wavelength increases, the amount of diffraction increases.

II. As slit width increases, the amount of diffraction decreases.

III. As wavelength increases, the amount of diffraction decreases.

Based on these observations alone, the correct conclusion(s) would be

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) II and III only

INTERFERENCE OF PERIODIC WAVES

1

S17A
II.1.d
S17C
II.5.a

75

F1
B1
A8

(D)

-

***

The diagram below shows a portion of a rope in which a disturbance XY travels in the direction of the arrow.

If the disturbance XY meets a similar disturbance travelling in the opposite direction, which one of the following configurations of the rope could <u>not</u> appear?

(A)

(B)

(C)

(D)

(E)

2 The waveform shown below was produced by a pair of superimposed waveforms.

S17A
II.1.d
S17C
II.5.a

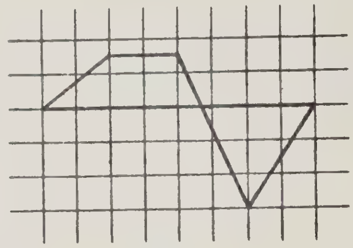
75

F1
A8
A7

(D)

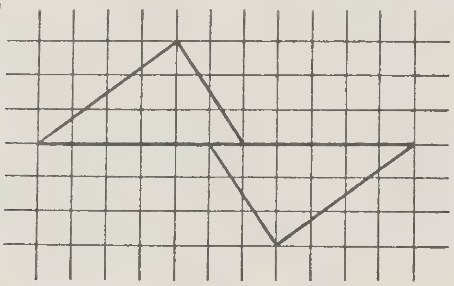
-

**

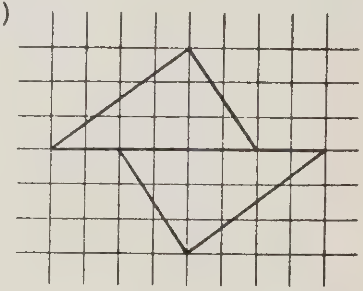


Which of the pairs of waveforms shown below when superimposed could produce the above waveform.

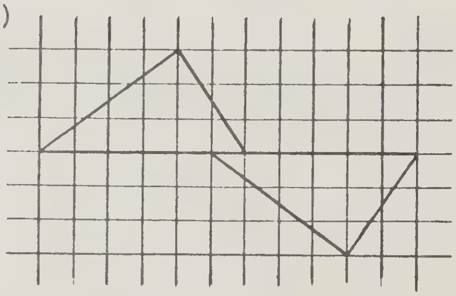
(A)



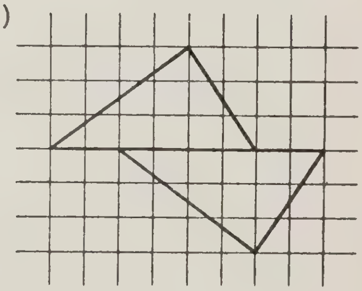
(B)



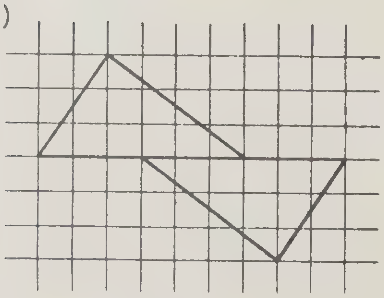
(C)



(D)



(E)



3

S17A
II.1.d
S17C
II.5.a

75

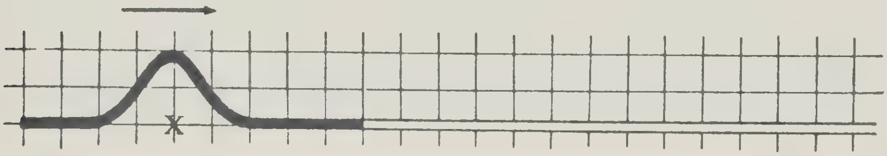
F1
B1

(E)

-

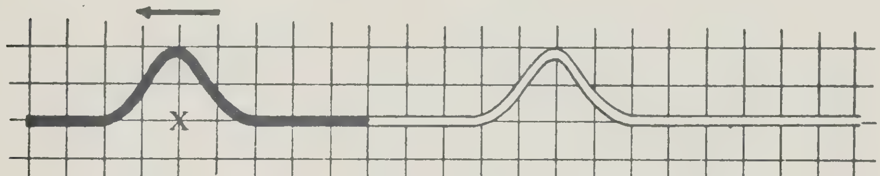
**

The diagram below shows a transverse pulse travelling along a heavy rope toward its junction with a lighter rope.

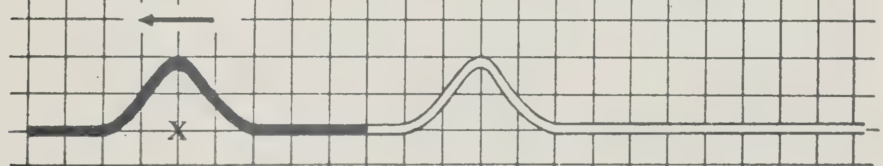


Which of the following diagrams best illustrates the ropes at the instant that the reflected pulse again passes through its original position marked X?

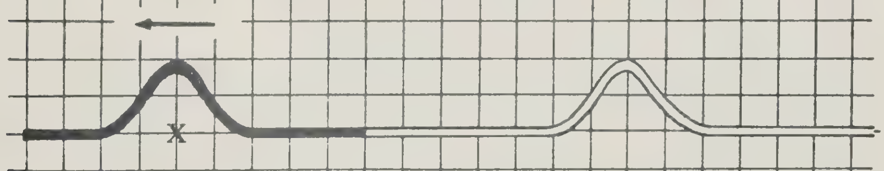
(A)



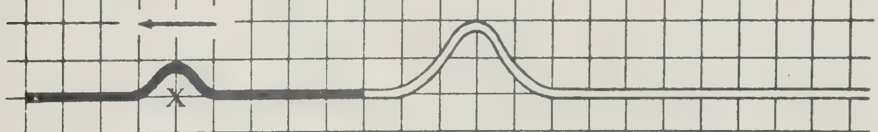
(B)



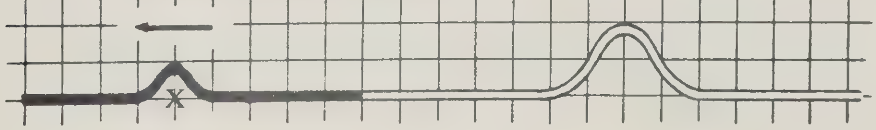
(C)



(D)



(E)



4

S17C
II.5.a

75
76

D3
A11
A1

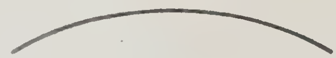
(C)

-

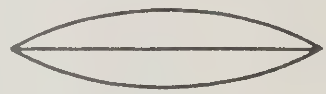
***

A string, vibrating with a constant frequency and amplitude, has its ends fixed in position. The string is observed by means of a flashing light. The flash frequency may be varied to produce different patterns of the string, but while a stationary pattern is being observed the flash frequency is kept constant. Which one of the following patterns could <u>not</u> be seen?

(A) 

(B) 

(C) 

(D) 

(E)

5

S17C
II.3.b

S 75

A8

(E)

-

**

When a transverse wave travelling on a string reaches the junction with a lighter string, the wave is

(A) totally reflected at the junction

(B) partially transmitted with a change in phase

(C) transmitted forming a standing wave pattern in the lighter string

(D) reflected so as to form a node at the junction

(E) partially reflected without a change in phase

6

S17C
II.3.b

S 75

A8
F1

(A)

-

**

The diagram below shows a pulse travelling to the right along a light rope attached to a heavy rope which is in turn attached to a light rope. The first and third ropes are identical.

A short time later the ropes will appear most like

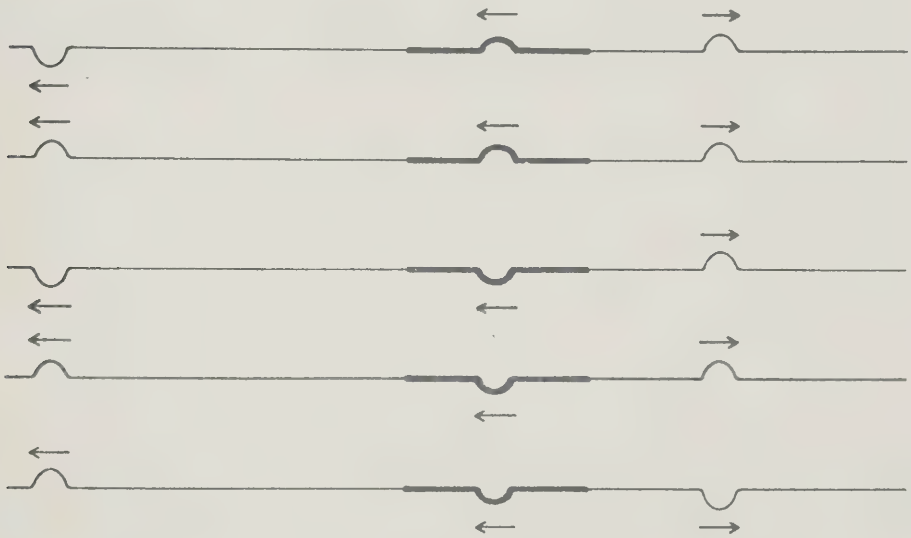
(A)

(B)

(C)

(D)

(E)



7

S17C
II.3.b

S 75

F1
A9
B1

(E)

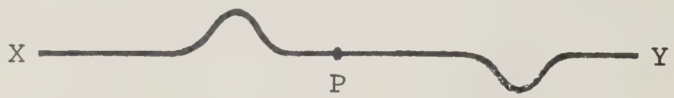
-

**

Two ropes XP and PY are joined together with a knot at P. An upward pulse such as that shown in the first figure (Pulse) is passed along the string to the knot, where part is transmitted and part is reflected.

Pulse

Shortly after this, the two pulses leaving the knot appear as shown in the second figure (After).



After

The conclusion to be drawn from the figures is that

(A) the pulse arrived from X, and XP is denser than PY

(B) the pulse arrived from X, and XP is less dense than PY

(C) the pulse arrived from Y, and XP and PY are equally dense

(D) the pulse arrived from Y, and XP is less dense than PY

(E) the pulse arrived from Y, and XP is denser than PY

8

S17A
II.1.d
S17C
II.5.a

77

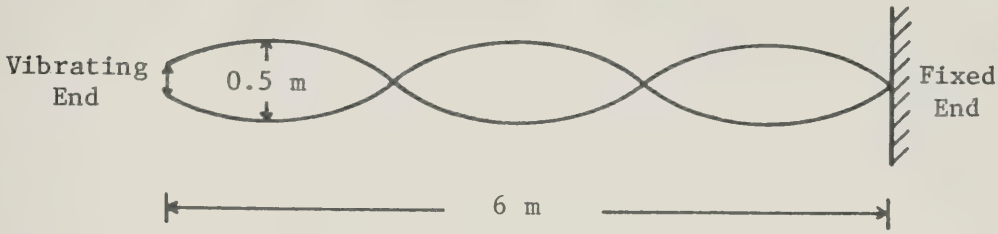
A2
A11

(E)

-

***

In an experiment to find the speed of waves in a rope, a standing wave pattern is established as shown. The vibrating end makes ninety vibrations per minute.



The wavelength is

(A) 0.25 m

(B) 0.5 m

(C) 1 m

(D) 2 m

(E) 4 m

9

S17A
II.1.d
S17C
II.5.a
S17C
II.4.b

S 77

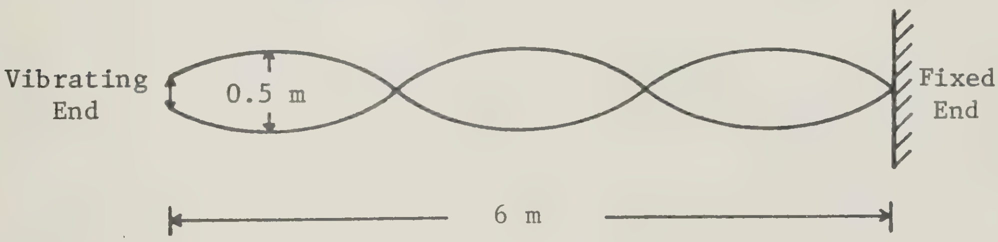
F1
A8

(B)

-

***

In an experiment to find the speed of waves in a rope, a standing wave pattern is established as shown. The vibrating end makes ninety vibrations per minute.



The speed of the waves is

(A) 3 m/s

(B) 6 m/s

(C) 180 m/s

(D) 360 m/s

(E) 540 m/s

10

S17C
II.5.a

S 77

F1

(B)

-

***

If light is a wave phenomenon, it should be possible to observe standing waves in reflection. Light of wavelength λ = 600 nm is normally incident on a metal mirror. If standing waves are formed, how far from the mirror would the first intensity maximum be found?

(A) 75 nm

(B) 150 nm

(C) 300 nm

(D) 450 nm

(E) 600 nm

11

S17A
II.1.a
S17C
II.5.a

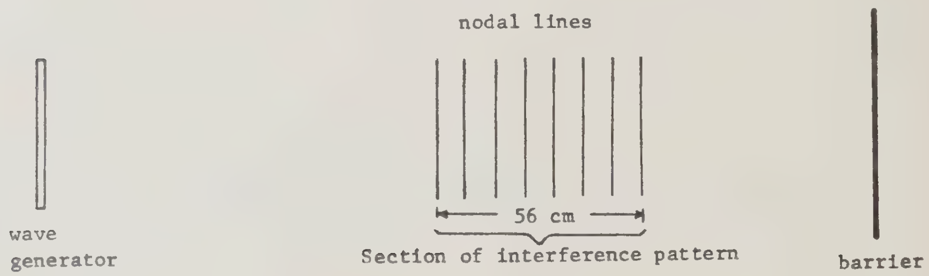
77

A3
A2
F1

(D)

***
***

The diagram below shows a standing wave pattern produced in a ripple tank by the reflection of plane waves from a straight barrier.



The wavelength of the waves, in centimetres, produced by the wave generator is

(A) 7.0

(B) 8.0

(C) 14

(D) 16

(E) 32

12

S17A
II.1.d
S17C
II.5.a

77

F1

(B)

***
***

Standing waves are produced in a string by two sources each having a frequency of 100 Hz. The distance from the 2nd node to the 5th node is 60 cm. The wavelength in centimetres of the original travelling wave is

(A) 50

(B) 40

(C) 30

(D) 20

(E) 15

13

S17A
II.1.a
S17C
II.5.a

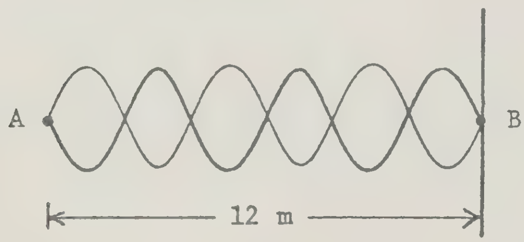
78

A2

(C)

**
***

Waves generated at A are reflected at B to produce a standing wave as shown in the diagram.



The number of antinodes in the diagram is

(A) 3

(B) 5

(C) 6

(D) 7

(E) 12

14

S17C
II.5.a

79

A8
F1

(C)

-

***

S_1 and S_2 are two point sources situated 6 cm apart, vibrating in phase, and producing waves having a wave-length of $\frac{5}{4}$ cm. (Diagram not drawn to scale.)

If P is a point on the first nodal line, then $PS_1 - PS_2$ will be equal to

(A) $\frac{5}{48}$ cm

(B) $\frac{5}{24}$ cm

(C) $\frac{5}{8}$ cm

(D) $\frac{5}{4}$ cm

(E) $\frac{15}{8}$ cm

15

S17C
II.5.a

79

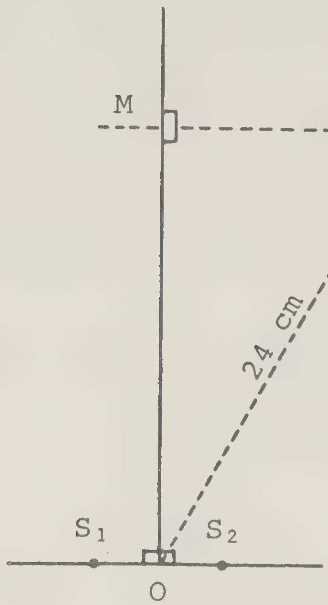
A8
F1

(C)

-

***

S_1 and S_2 are two point sources situated 6 cm apart, vibrating in phase, and producing waves having a wavelength of $\frac{5}{4}$ cm. (Diagram not drawn to scale.)



If Q is a point on the <u>second</u> nodal line, 24 cm away from O, then MQ is approximately

(A) 2.5 cm

(B) 5 cm

(C) 7.5 cm

(D) 10 cm

(E) 15 cm

16

S17C
II.5.a

79

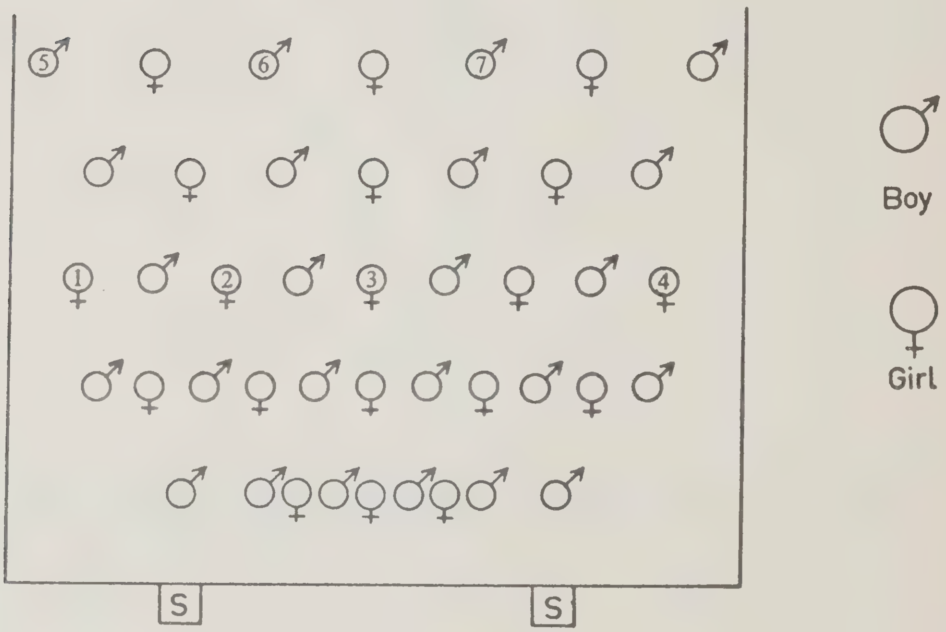
F1
A8
A3

(B)

-

**

On a day when there is no wind, a loudspeaker S is placed at each goalpost at one end of a football field. The loudspeakers are in phase and are emitting sounds of the same constant frequency and intensity. The boys in a class are asked to find positions on the field where the sound is faintest and the girls to find positions where the sound is loudest. The positions taken are shown in the diagram below.



Which girl is at a point one wavelength further from one loudspeaker than from the other?

(A) 1

(B) 2

(C) 3

(D) 4

(E) None of the above

17

S17C
II.5.a

79

A3
A1

(B)

-

***

When two point sources placed a fixed distance apart vibrate in phase, nodal lines are produced. Which one of the following statements concerning these lines is <u>incorrect</u>?

(A) Energy is transmitted away from the sources between the nodal lines.

(B) At large distances from the sources, nodal lines have a uniform separation of half a wavelength.

(C) There is a constant path difference from the point sources to any point on a given nodal line.

(D) Destructive interference occurs on nodal lines.

(E) All nodal lines are hyperbolic.

18

S17C
II.5.a

79

F1

(D)

-

***

Two point-sources in a ripple tank vibrate in phase at a frequency of 12 Hz to produce waves having a wavelength 0.024 m. The difference in path-length from the two point-sources to a point on the second nodal line is

(A) 0.6 cm

(B) 1.2 cm

(C) 2.4 cm

(D) 3.6 cm

(E) 4.8 cm

19

S17C
II.5.a

79

F1
A8

(D)

***
**

A nodal line pattern is produced by two point sources vibrating in phase in a ripple tank. A point P is selected on the second nodal line so that it is 37 cm from one source and 28 cm from the other source. The wavelength of the waves in centimetres is

(A) 18

(B) 13.5

(C) 9.0

(D) 6.0

(E) 4.5

20

S17C
II.5.a

79

A1

(E)

_

*

Two periodic point sources vibrating in phase produce an interference pattern on a water surface.

The path difference between the two point sources and a point on the n^{th} nodal line is

(A) $n\lambda$

(B) $(n - 1)\lambda$

(C) $(n + 1)\lambda$

(D) $(n + \frac{1}{2})\lambda$

(E) $(n - \frac{1}{2})\lambda$

21

S17C
II.5.b

80

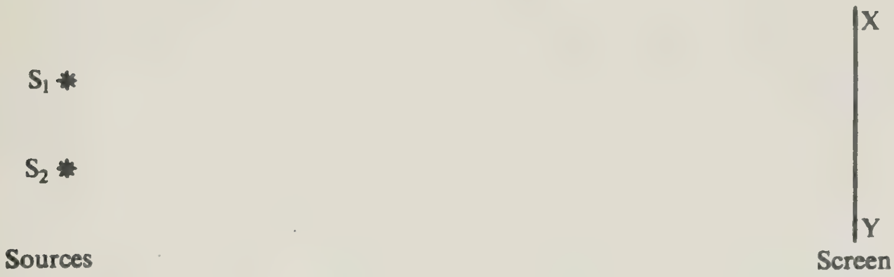
A1
B1
A5
A8

(D)

-

***

S_1 and S_2 are two point sources of light that produce a set of interference bands on the screen. Initially S_1 and S_2 are in phase.



As the phase of S_1 is delayed with respect to S_2, which one of the following effects will be observed on the screen?

(A) The interference pattern will disappear.

(B) The band separation will increase.

(C) The band separation will decrease.

(D) The band system will move toward X.

(E) The band system will move toward Y.

WAVE MODEL OF LIGHT AND INTERFERENCE

1

S17A
II.3.a
S17C
II.6.d

82

F1
A8

(B)

–

***

A narrow beam of light travels from a vacuum into a substance S at an angle of incidence of 45^0. The light has a frequency of 6.00×10^{14} Hz in the vacuum and a speed of 2.13×10^8 m/s in the substance S. (The speed of light in a vacuum is 3.00×10^8 m/s.)

The index of refraction of S is

(A) 0.707

(B) 1.41

(C) 1.50

(D) indeterminable from the data given but less than 1.00

(E) indeterminable from the data given but greater than 1.00

2 The diagram below illustrates a series of wave fronts travelling from a shallow to a deep portion of a tank of water.

S17C
II.6.d

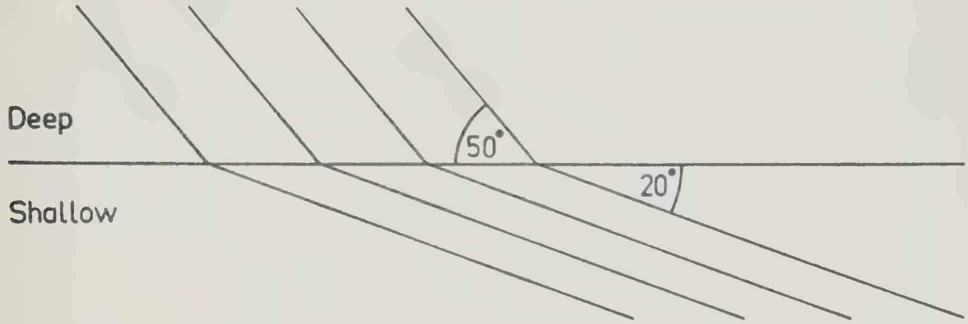
82

A8
F1

(B)

-

***



The ratio of the speed of the waves in the deep portion to that in the shallow portion is equal to

(A) $\frac{\sin 20^0}{\sin 50^0}$

(B) $\frac{\sin 50^0}{\sin 20^0}$

(C) $\frac{\sin 30^0}{\sin 40^0}$

(D) $\frac{\sin 40^0}{\sin 70^0}$

(E) $\frac{\sin 70^0}{\sin 40^0}$

3

S17A
II.3.a
S17C
II.6.d

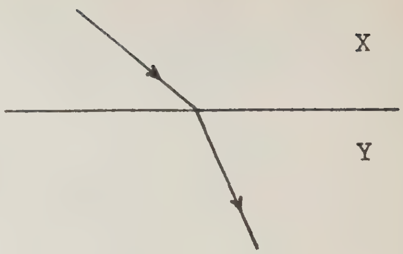
82

A3

(C)

***
**

When light travels from medium X to medium Y



(A) both the speed and the frequency decrease

(B) both the speed and the frequency increase

(C) both the speed and the wavelength decrease

(D) both the speed and the wavelength increase

(E) both the speed and the frequency are unchanged

4

S17A
II.3.a
S17C
II.6.d

82

A1
F1
A11

(D)

-

***

A hollow lens is made of thin glass as shown in the diagram. The lens may be filled with air, water (index of refraction = 1.3), or carbon disulphide (index of refraction = 1.6).

The lens will diverge a beam of parallel rays when

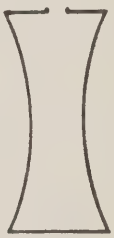
(A) it is filled with air and immersed in air

(B) it is filled with air and immersed in water

(C) it is filled with water and immersed in carbon disulphide

(D) it is filled with carbon disulphide and immersed in water

(E) it is filled with carbon disulphide and immersed in carbon disulphide



5 The index of refraction of a type of glass is 1.5. The speed of light in this glass is

S17A
II.3.a
S17C
II.6.d

82

F1
A8

(D)

**
***

(A) 4.5×10^8 m/s

(B) 3×10^8 m/s

(C) 2.25×10^8 m/s

(D) 2×10^8 m/s

(E) 1.5×10^8 m/s

6 The absolute index of refraction of glass is 1.50 and of oil is 1.20. The relative index of refraction for light travelling from glass into oil is

S17C
II.6.d

82

F1
A8

(B)

-
***

(A) 0.300

(B) 0.800

(C) 1.25

(D) 1.80

(E) impossible to calculate with the information given

7 A narrow beam of light travels from a vacuum into a substance S at an angle of incidence of 45°. The light has a frequency of 6.00×10^{14} Hz in the vacuum and a speed of 2.13×10^8 m/s in the substance S. (The speed of light in a vacuum is 3.00×10^8 m/s.) The frequency of the waves in substance S, in Hz, is

S17C
II.6.d
S17C
II.4.b

82

A8

(E)

-
***

(A) $\frac{6.00}{2.13} \times 10^6$

(B) $\frac{6.00}{1.41} \times 10^{14}$

(C) 1.41×10^{14}

(D) $6.00 \times 1.41 \times 10^{14}$

(E) 6.00×10^{14}

8 Each of the following graphs represents light being transmitted through the same glass block. Which one of the waves travels through the glass with the greatest speed?

S17C
II.6.d

82

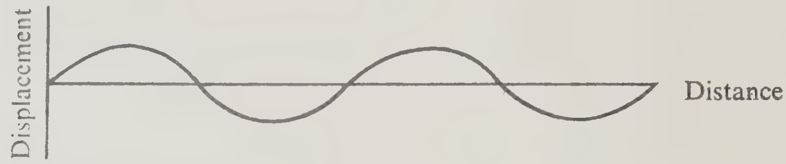
A8

(D)

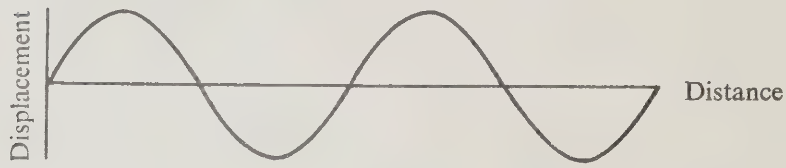
-

***

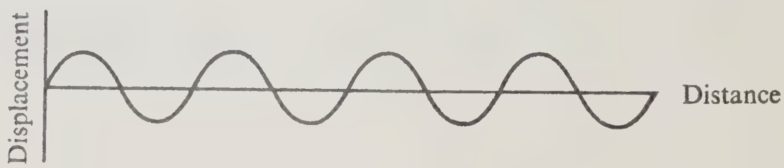
(A)



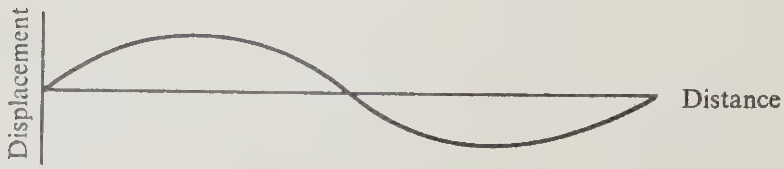
(B)



(C)



(D)



(E) All of the waves are transmitted with the same speed.

9

S17C
II.6.d

S 82

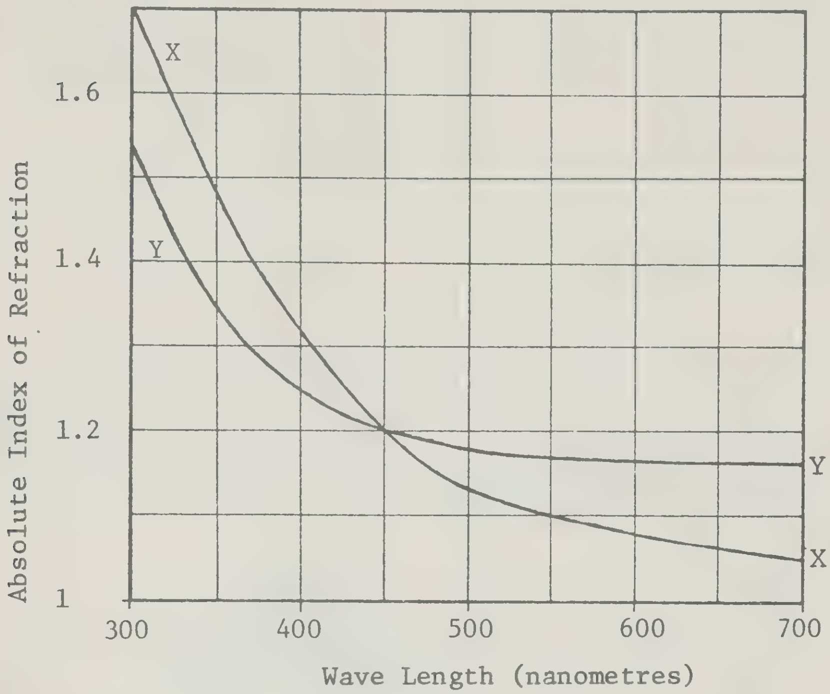
All

(B)

-

***

The graph below shows the absolute index of refraction of two substances, X and Y, as a function of wave length. (All wave lengths given are measured in a vacuum.)



The dispersion of a substance is the rate of change of the index of refraction of the substance with respect to wave length. The graph indicates that the dispersion of X and Y is the same for light whose wave length in nanometres is about

(A) 120

(B) 320

(C) 450

(D) 500

(E) 620

10

S17C
II.6.a

84

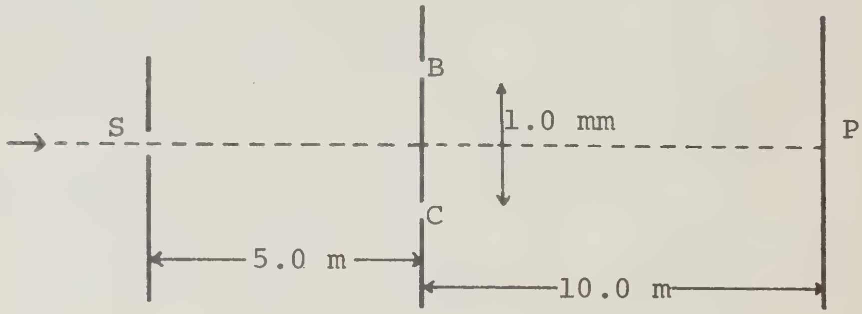
B1
A11

(C)

-

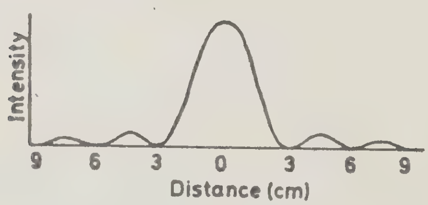
***

Monochromatic light coming from the left passes through a slit S and then falls on a metal sheet with two slits B and C as shown below. The slits are the same width. The light then falls on a screen, giving rise to characteristic intensity patterns centred at P.

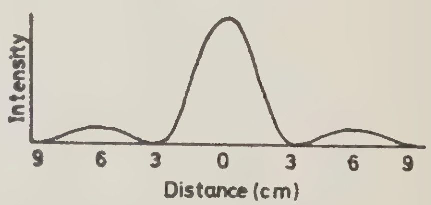


Which of the intensity patterns is characteristic of this arrangement?

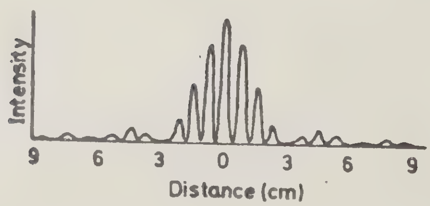
(A)



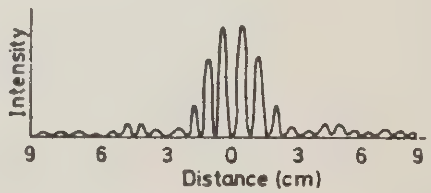
(B)



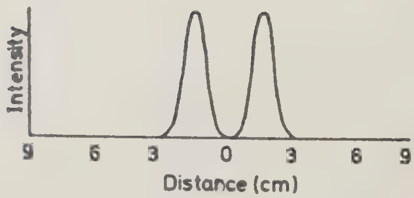
(C)



(D)



(E)



11

S17C
II.6.c

84

A10
A3

(C)

-

***

When gasoline is poured on water, colours are frequently observed. This effect is produced primarily by

(A) diffraction

(B) diffuse reflection

(C) interference

(D) absorption

(E) incandescent molecules

12

S17C
II.6.c

S 84

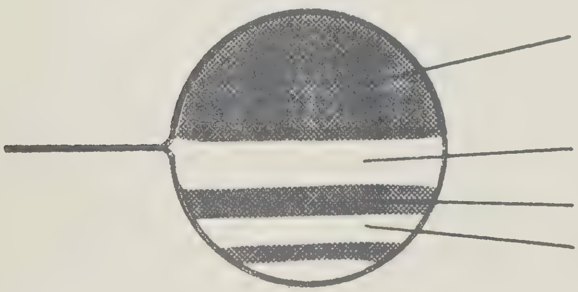
D3
E3

(E)

-

***

A wire loop which has been dipped into a soap solution is held vertically. The film is viewed by the reflection of yellow light. At one instant the appearance of the film is as shown in the diagram.



Choose the statement that best explains the large dark space at the top.

(A) No light is transmitted in this region.

(B) The thickness of the film is $\frac{1}{4}$ of the wavelength of yellow light.

(C) The light reflected from the second surface undergoes an inversion.

(D) The film is too thick to reflect light of this wavelength.

(E) The rays reflected from the first and second surfaces are opposite in phase.

13

S17C
II.6.c

S 84

A1
A8
A3

(B)

-

***

Red light of wavelength λ is viewed through a thin soap film held vertically. At the second dark area from the top the thickness of the film is

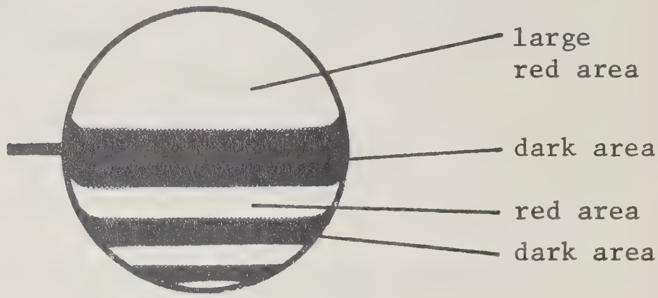
(A) λ

(B) $\frac{3}{4}\lambda$

(C) $\frac{\lambda}{2}$

(D) $\frac{\lambda}{4}$

(E) very much less than λ



14

S17C
II.6.c

S 84

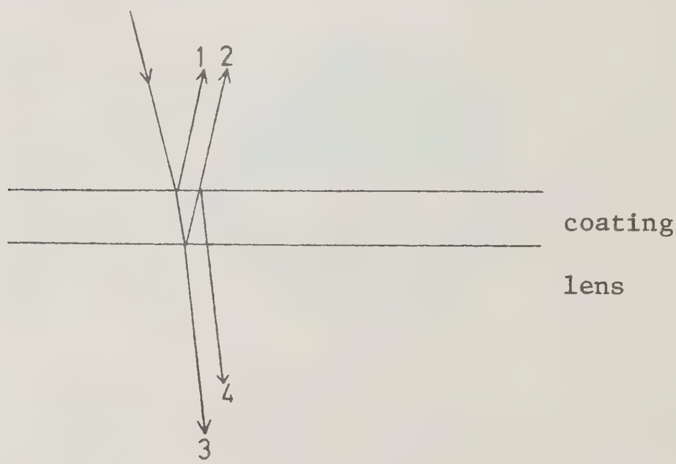
F1
A8

(E)

-

**

Binoculars and microscopes are frequently made with "coated optics" by adding a thin layer of transparent material to the exterior surface of the lens.



The condition necessary for maximum transmission of light energy is

(A) constructive interference of the light energy between 1 and 2

(B) the coating must be more transparent than the lens

(C) destructive interference between 3 and 4

(D) the velocity of light in the coating must be less than that in the lens

(E) the total light energy reflected is a minimum

15

S17C
II.6

85

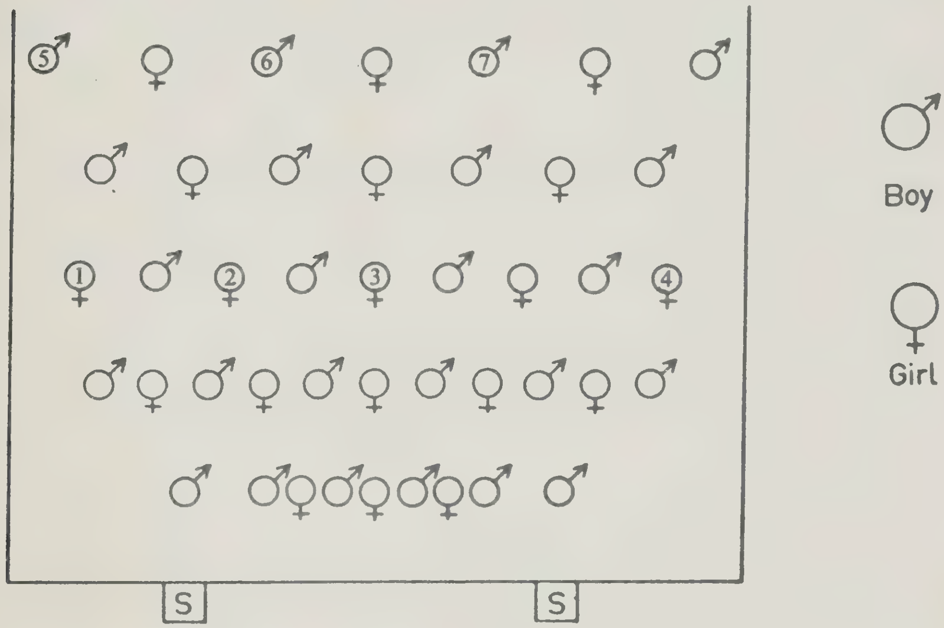
F1
A8
A3

(C)

-

***

On a day when there is no wind, a loudspeaker S is placed at each goalpost at one end of a football field. The loudspeakers are in phase and are emitting sounds of the same constant frequency and intensity. The boys in a class are asked to find positions on the field where the sound is faintest and the girls to find positions where the sound is loudest. The positions taken are shown in the diagram below.



Which one of the following changes would result in the students standing closer together?

(A) Increasing the wavelength of the note emitted

(B) Moving the loudspeakers closer together

(C) Increasing the frequency of the note emitted

(D) Choosing a day when the air temperature is much higher

(E) Putting the loudspeakers out of phase

16

S17C
II.6.a

S 85

D3
F1
A8

(E)

–

***

Figure I, the double slit pattern seen with a monochromatic light source, is changed to the pattern of Figure II.

Fig I

Fig II

Consider the following possible changes in conditions:

1. The frequency of the source was decreased.
2. The frequency of the source was increased.
3. The width of each slit was increased.
4. The separation of the slits was increased.
5. The separation of the slits was decreased.

Which selection(s) of the above changes would explain the alteration of the pattern?

(A) 3 only

(B) 5 only

(C) 1 and 3 only

(D) 1 and 5 only

(E) 2 and 4 only

17

S17C
II.5.a

S 85

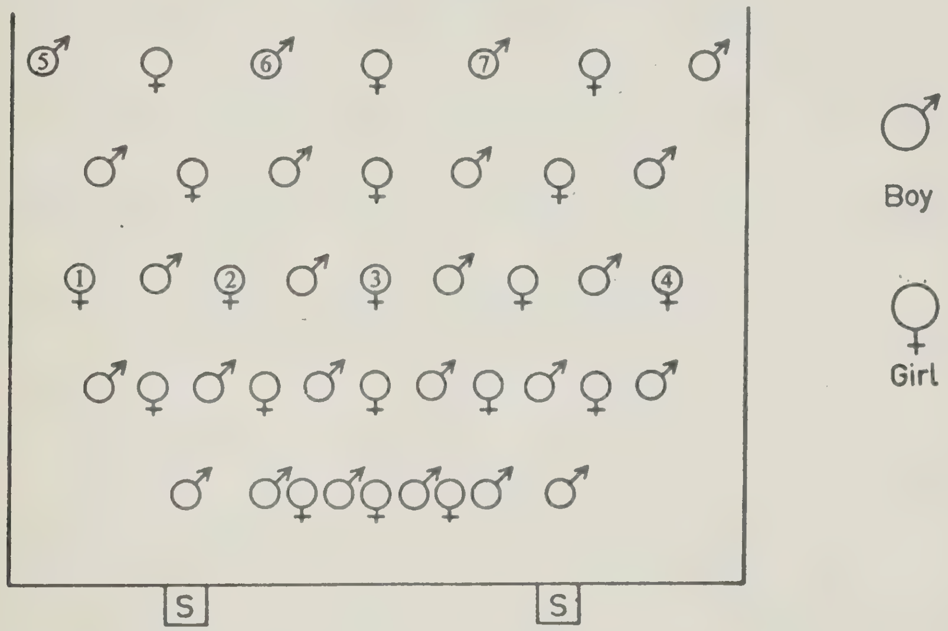
F1
A8

(C)

\-

***

On a day when there is no wind, a loudspeaker S is placed at each goalpost at one end of a football field. The loudspeakers are in phase and are emitting sounds of the same constant frequency and intensity. The boys in a class are asked to find positions on the field where the sound is faintest and the girls to find positions where the sound is loudest. The positions taken are shown in the diagram below.



Which student is at a position with best satisfies the conditions $\frac{X}{L} = \frac{3\lambda}{2d}$?

X = the distance from the student to the right bisector of the line joining the loudspeakers

L = the distance of the student from the midpoint between the speakers

λ = the wavelength of the sound from the speakers

and d = the distance between the speakers

(A) 2

(B) 4

(C) 5

(D) 6

(E) 7

18

S17C
II.6.a

85

A8
F1

(B)

-

***

A double slit interference pattern was produced using light of wavelength 400 nm. The distance between the slits was 0.50 mm and the slits were located 2.0 m from the screen. ($1 \text{ nm} = 10^{-9} \text{ m}$)

In order to increase the width of each band, one should

(A) double both the distance between the slits and their distance from the screen

(B) halve the distance between the slits and double their distance from the screen

(C) double the distance between the slits and halve their distance from the screen

(D) halve both the distance between the slits and their distance from the screen

(E) decrease the distance between source and slit

19

S17C
II.6.a

85

F1
A8

(E)

-

***

When two thin slits are illuminated with red light, the interference pattern observed on a distant screen has regions of maximum illumination separated by 0.2 cm. If blue light of half the wavelength were used instead, and the slits were spaced twice as far apart, the spacing between the blue fringes on the screen would be

(A) 0.8 cm

(B) 0.4 cm

(C) 0.2 cm

(D) 0.1 cm

(E) 0.05 cm

20

S17C
II.6.a

85

A8
F1

(B)

-

***

A student sets up Young's double slit experiment by allowing light of wavelength 600 nm coming from a narrow source to fall on two narrow parallel slits in an opaque barrier. Light which passes through the slits falls on a screen. The student observes on the screen a pattern of alternating light and dark lines. If the student leaves the rest of the experiment unchanged, but replaces the light source with a similar one, in the same position, producing light of wavelength 450 nm, which of the following would be true?

(A) The spacing of the light and dark lines on the screen would be unchanged.

(B) The spacing of the light and dark lines on the screen would be about 3/4 of that in the first experiment.

(C) The spacing of the light and dark lines on the screen would be about 4/3 of that in the first experiment.

(D) No pattern of light and dark lines would be produced unless the spacing of the two slits was changed to about 3/4 of that in the first experiment.

(E) No pattern of light and dark lines would be produced unless the spacing of the two slits was changed to about 4/3 of that in the first experiment.

21

S17C
II.6.a

85
86

F1

(C)

-

***

Violet light of 340 nm wavelength falls on a double slit, and 2.0 m away on a screen, dark interference bands are formed 3.4 mm apart (1 nm = 10^{-7} cm). The distance between the two slits is

(A) 2 cm

(B) 0.2 cm

(C) 0.02 cm

(D) 0.002 cm

(E) none of these

22

S17C
II.6.a

85

F1
A8

(E)

-

***

Violet light of 340 nm wavelength falls on a double slit, and 2.0 m away on a screen, dark interference bands are formed 3.4 nm apart. If the wavelength of the light were doubled, the distance from the double slit to the screen were doubled, and the distance between the two slits were halved, then the separation between the dark interference bands would be multiplied by a factor of

(A) $\frac{1}{8}$

(B) $\frac{1}{2}$

(C) 2

(D) 4

(E) 8

23

S17C
II.6.a

85

D3
A1
A9

(B)

**
**

Which one of the following statements is correct, according to the results of double slit experiments with light?

(A) Red light has a longer wavelength than blue light since the dark lines in the interference pattern for red light are closer together than those for blue light.

(B) Red light has a longer wavelength than blue light since the dark lines for red light are farther apart than those for blue light.

(C) Blue light has a longer wavelength than red light since the dark lines for blue light are closer together than those for red light.

(D) Blue light has a longer wavelength than red light since the dark lines for blue light are farther apart than those for red light.

(E) Red light and blue light have the same wavelength since identical interference patterns are seen through a double slit.

24

S17C
II.6.a

85

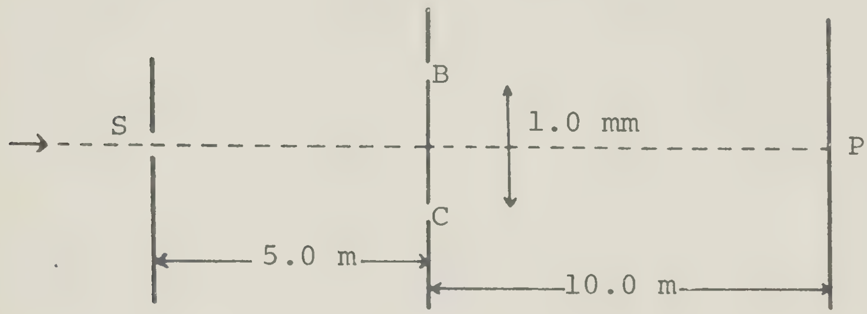
B1
A11

(D)

\-

***

Monochromatic light coming from the left passes through a slit S and then falls on a metal sheet with two slits B and C as shown below. The slits are the same width. The light then falls on a screen giving rise to characteristic intensity patterns centred at P.



Which of the following alterations to the experimental arrangement will not result in a change in the intensity pattern?

(A) The separation between slits B and C is increased.

(B) The width of slits B and C is decreased.

(C) The distance from the metal sheet to the screen is decreased.

(D) The distance from S to the metal sheet is increased.

(E) The wavelength of the incident light is decreased.

25

S17C
II.6.a

85

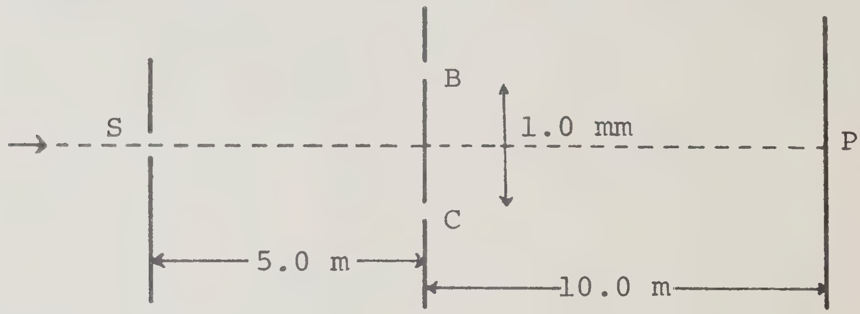
F1
A8
A11

(D)

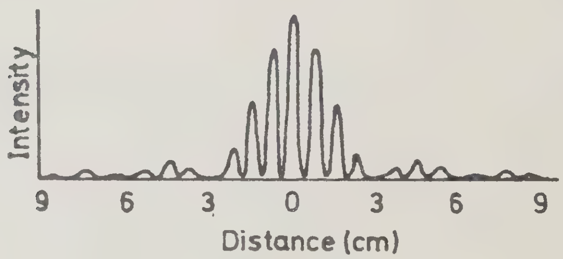
\-

***

Monochromatic light coming from the left passes through a slit S and then falls on a metal sheet with two slits B and C as shown below. The slits are the same width. The light then falls on a screen.



The intensity pattern shown below is centred at P.



The wavelength of the light is closest to

(A) 1.5×10^{-5} cm

(B) 4.5×10^{-5} cm

(C) 5.0×10^{-5} cm

(D) 7.5×10^{-5} cm

(E) 15×10^{-5} cm

26

S17C
II.6.a

85

F1
A8

(C)

-

**

Light of wavelength 600 nm passes through a double slit. Bright interference bands appear 6 mm apart on a screen a fixed distance from the slits. If the source is replaced by a light of 450 nm, the distance between the adjacent dark bands becomes

(A) 2.25 mm

(B) 4 mm

(C) 4.5 mm

(D) 6 mm

(E) 8 mm

27

S17C
II.6.a

85

F1

(E)

-

**

Two point sources in phase create an interference pattern in a ripple tank. If the frequency of both sources is doubled, the number of nodal lines

(A) is 4 times as great

(B) is 1/2 as great

(C) depends on the accompanying phase change

(D) remains constant

(E) is doubled

28

S17C
II.6.a

85

F1
A8

(D)

-

***

A student observes the interference pattern produced when light from a straight filament light bulb covered with a yellow filter passes through a double slit. Which of the following changes would cause a smaller spacing of the nodal lines?

(A) Use slits that are closer together.

(B) Use a light source of lower intensity.

(C) Use a light source of higher intensity.

(D) Use a blue filter in place of the yellow.

(E) Move the light source further from the double slit.

29

S17C
II.6.a

85

F1
A8

(C)

***

Waves are produced by two point sources S_1 and S_2 vibrating in phase. P is a point on the third nodal line; the path difference $S_1P - S_2P$ is 5.0 cm.

The wavelength of the waves is

(A) 1.4 cm

(B) 1.7 cm

(C) 2.0 cm

(D) 2.5 cm

(E) 3.3 cm

30

S17C
II.5.a

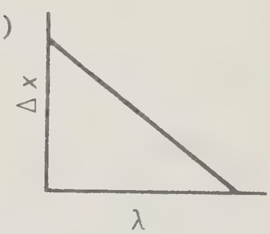
S 85

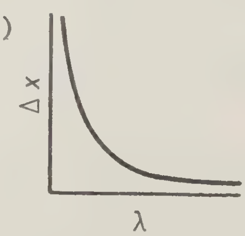
A8
A11

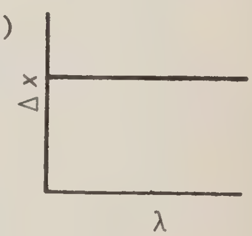
(D)

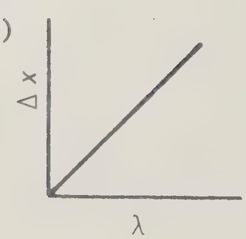
***

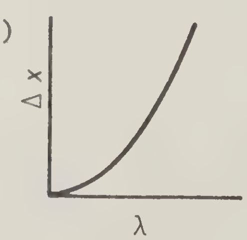
Water waves pass through a double slit in a wax block in a ripple tank. The graph that best represents the relationship between the separation Δx of the nodal lines and the wavelength λ of the waves is

(A)


(B)


(C)


(D)


(E)


31

S17C
II.5.a

85
86

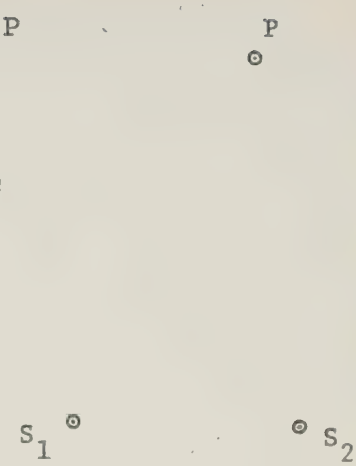
B3

(C)

-

**

In the diagram to the right, point P is on the third nodal line in a ripple tank interference pattern. The pattern, drawn to scale, was created by two sources S_1 and S_2 vibrating in phase. Using a metric ruler, the wavelength of the interfering waves is closest to



(A) 4 mm

(B) 3 mm

(C) 2 mm

(D) 1 mm

(E) 0.5 mm

32

S17C
II.6.b

87

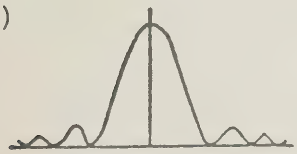
D3
A1

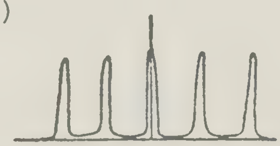
(A)

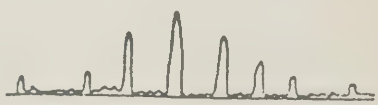
-

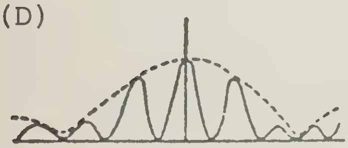
*

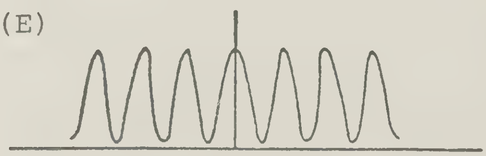
A single slit is illuminated by parallel light and a diffraction pattern is formed on a screen some distance away. Which one of the following diagrams best represents the intensity distribution across the screen?

(A)


(B)


(C)


(D)


(E)


33

S17C
II.6.b

87

F1
A5
A1

(E)

\-

***

A characteristic diffraction pattern is produced when yellow light illuminates a narrow slit as shown in Fig. I.

Fig. I

A second identical slit is placed between the source and the first slit as shown in Fig. II.

Fig. II

Which one of the following changes occurs in the pattern?

(A) Twice as many maxima occur.

(B) The minima are farther apart.

(C) The pattern becomes a single bright line.

(D) Every second maximum is eliminated.

(E) The maxima are dimmer.

34 Monochromatic light coming from the left passes through a slit S and then falls on a metal sheet with a single slit A. The light then falls on a screen giving rise to characteristic intensity patterns centred at P.

S17C
II.6.b

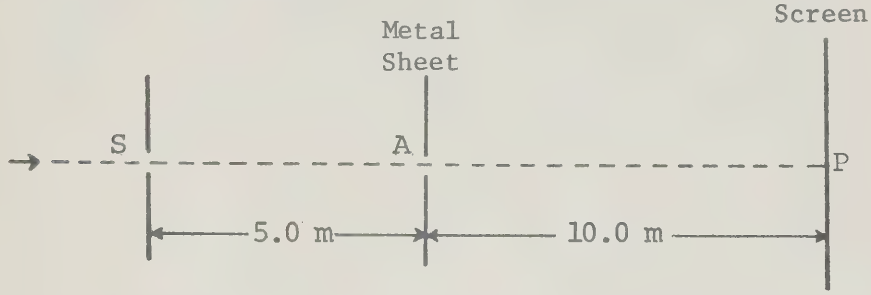
87

B1
A11

(A)

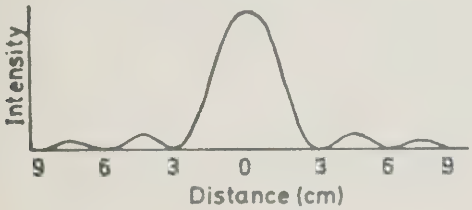
-

***

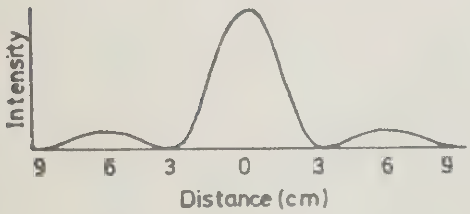


Which of the intensity patterns is characteristic of this arrangement?

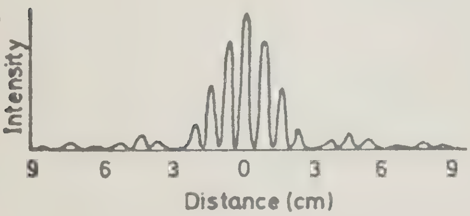
(A)



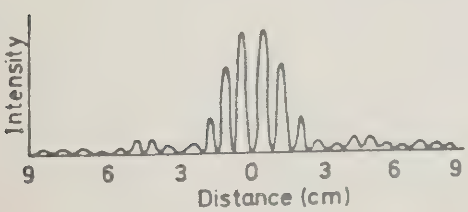
(B)



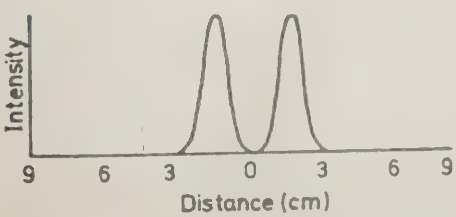
(C)



(D)



(E)



35

S17C
II.6.b

87

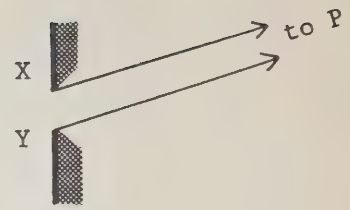
A8

(D)

-

***

The diagram on the right shows a single slit with the direction to a point P in the diffraction pattern indicated. X and Y are the edges of the slit. Which path difference PY-PX would place P at the second minimum intensity from the central maximum?



(A) $\frac{\lambda}{2}$

(B) λ

(C) $\frac{3\lambda}{2}$

(D) 2λ

(E) $\frac{5\lambda}{2}$

36

S17C
II.6.b

87

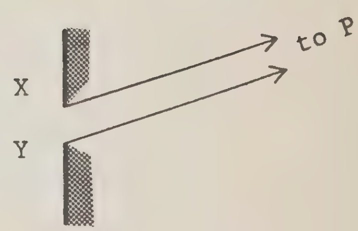
A8

(C)

-

***

The diagram on the right shows a single slit with the direction to a point P in the diffraction pattern indicated. X and Y are the edges of the slit. Which path difference PY-PX would place P at the maximum intensity nearest the central maximum?



(A) $\frac{\lambda}{2}$

(B) λ

(C) $\frac{3\lambda}{2}$

(D) 2λ

(E) $\frac{5\lambda}{2}$

37

S17C
II.6.b

87

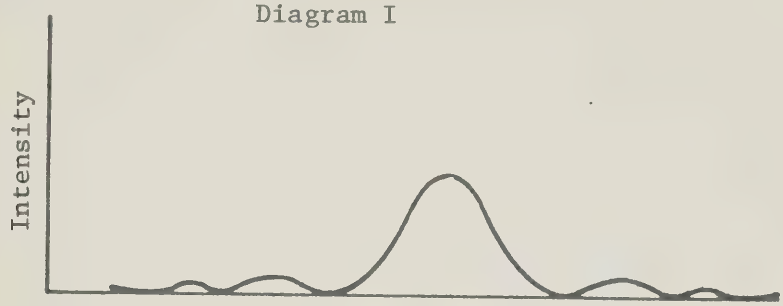
B1
A8
A5

(E)

-
***

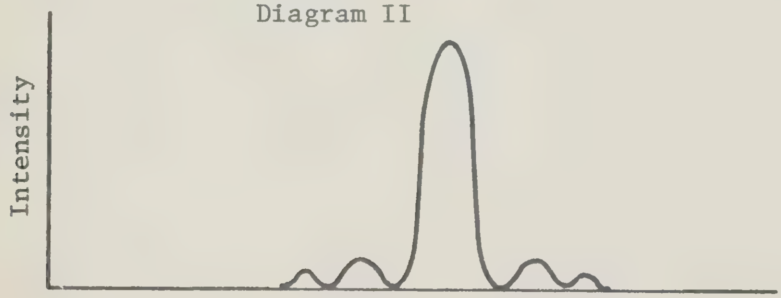
Light from a small source passed through a single narrow slit to a distant screen, producing a diffraction pattern. Diagram I is a graph of the intensity of light against position on the screen.

Diagram I



In a second experiment, the graph of Diagram II, drawn to the same scale, was obtained.

Diagram II



Which one of the following changes in the experimental conditions could have caused the observed change?

(A) A narrower slit was used.

(B) Light of larger wavelength was used.

(C) The distance from source to slit was decreased.

(D) The distance from source to slit was increased.

(E) The distance from slit to screen was decreased.

38

S17C
II.6.d

S 88

F1

(A)

\-

***

The scattering of light by the earth's atmosphere varies inversely as the fourth power of the wavelength. The ratio of the amount of scattering of red light ($\lambda_{red} = 6 \times 10^{-7}$ m) to that of violet light ($\lambda_{violet} = 4 \times 10^{-7}$ m) is closest to

(A) 1 to 5

(B) 4 to 9

(C) 2 to 3

(D) 3 to 2

(E) 5 to 1

39

S17C
II.6.d

S 88

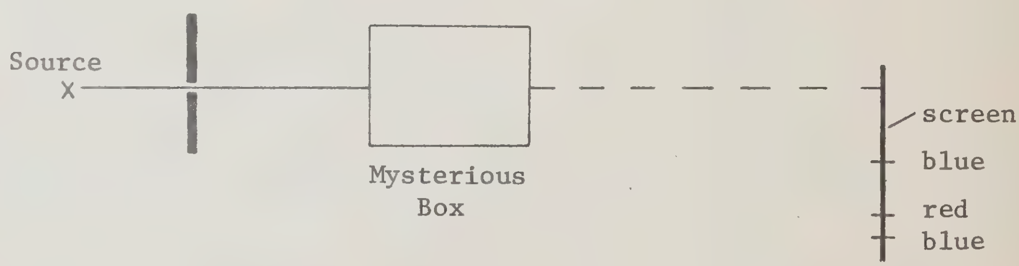
D3
F1
E2

(D)

\-

***

Light radiating from a point source X contains only blue and red components. After passing through a mysterious box the light falls on a screen. Red and blue bands are observed on the screen in the positions shown in the diagram below.



The most likely content of the mysterious box is

(A) a lens

(B) a mirror

(C) a prism

(D) a double slit

(E) a blue and a red filter

40 Which phenomenom is evidence of the transverse nature of light waves?

S17C
II.6.d

88

A1
A3

(E)

\-

***

(A) refraction

(B) reflection

(C) diffraction

(D) interference

(E) polarization

41 The phenomena of light bending as it passes from air into oil is described as

S17C
II.6.d

S 88

A2

(A)

*
*

(A) refraction

(B) diffraction

(C) interference

(D) specular reflection

(E) diffuse reflection

42 Which of the following properties of light is <u>not</u> consistent with the simple wave model for light?

S17C
II.6.d

88
74
81
82
83

E3

(C)

\-

***

(A) Light travels in straight lines.

(B) The speed of light in air is greater than in water.

(C) Light can travel through a vacuum.

(D) Light can be diffracted.

(E) Light can be simultaneously reflected and transmitted at the interface of two media.

ELECTRICITY

AND

MAGNETISM

ELECTRIC FORCES AND CHARGES

1

S17C
III.1.a

89

A1
A3

(C)

**
-

The leaves of a positively charged electroscope diverge more when a charged object is brought near the knob of the electroscope. The object must be

(A) a conductor

(B) an insulator

(C) positively charged

(D) negatively charged

(E) neutral

2

S17A
III.1.a

89

C3

(D)

**
-

You are given a plastic ruler which has been charged electrically by rubbing it with a cloth.

Consider the following procedures:

I. Bring the ruler toward a positively charged pith ball.

II. Bring the ruler toward a negatively charged pith ball.

III. Bring the ruler toward a neutral pith ball.

Which of the above procedures can be used to determine the sign of the charge on the ruler?

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) I, II and III

3

S17A
III.1.b

S 89

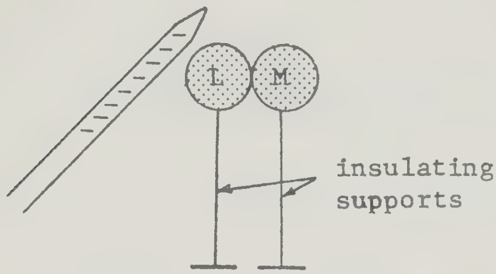
A5
F1

(E)

**

-

Two neutral metal spheres, L and M are in contact. A negatively charged rod is brought close to but not touching L. The spheres are then separated while the negative rod is kept near sphere L.



After the spheres are separated and the charged rod is removed

(A) both spheres will be neutral

(B) both spheres will be positively charged

(C) both spheres will be negatively charged

(D) sphere L will be negatively charged and sphere M will be positively charged

(E) sphere L will be positively charged and sphere M will be negatively charged

4

S17A
III.1.b

89

D3
A10

(D)

***
-

Object P is negatively charged. An insulated conductor Q experiences a force of electrostatic repulsion when brought near P and a force of electrostatic attraction when brought near a third object R. The charge on R

(A) can only be positive

(B) can only be negative

(C) can only be neutral

(D) may be either positive or neutral

(E) may be either positive or negative

5
S17A
III.1.c
S 89
A5
A7
(A)
***
–

A metal leaf electroscope is charged by induction with a negatively charged rod. Consider the following statements.

I. The electroscope becomes positively charged.

II. The electroscope becomes negatively charged.

III. Some negative charge moves from the electroscope into the ground.

IV. Some positive charge moves from the ground into the electroscope.

Which two of the above statements are correct?

(A) I and III

(B) I and IV

(C) II and III

(D) II and IV

(E) III and IV

6
S17C
IV.1.a
91
F1
A8
(E)
–
***

When two small charged spheres are separated by 2.0 m, the electrical force of attraction between them is 6.0 N. If the charge on each sphere is doubled and the separation is reduced to 1.0 m, the force of attraction will now be

(A) 6 N

(B) 16 N

(C) 24 N

(D) 48 N

(E) 96 N

7

S17C
IV.1.a

91

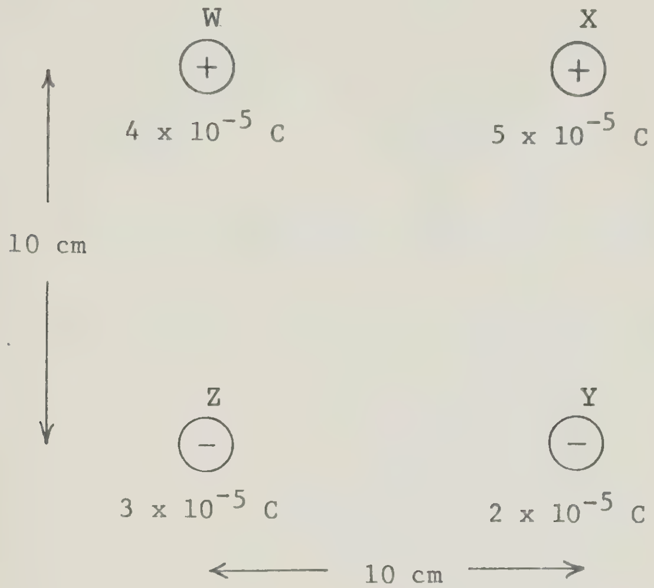
F1

(C)

\-

***

Four charged spheres, W, X, Y and Z are arranged as illustrated in the following diagram. The sign and magnitude of each charge is shown.



Which two spheres exert the smallest force on each other?

(A) W and X

(B) Z and Y

(C) W and Y

(D) X and Z

(E) W and Z

8

S17C
IV.1.a

91
37

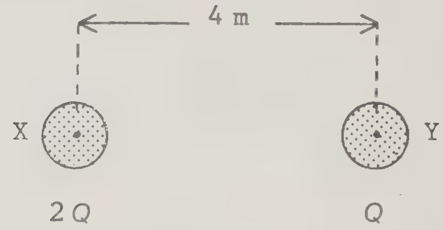
F1

(C)

-

***

Two spheres, X and Y, are 4 m apart. A charge of $2Q$ is distributed over sphere X and a charge of Q is distributed over sphere Y.



The magnitude of the electrostatic force on X is

(A) 4 times that on Y

(B) 2 times that on Y

(C) the same as that on Y

(D) one-half that on Y

(E) one-quarter that on Y

9

S17C
IV.1.b

92

F1

(E)

-

***

Two small spheres, having positive charges of X units and Y units respectively, are located 10 m apart. A test charge of +1 unit is located between them as illustrated. The net electrical force on the test charge is zero.

The ratio X:Y is

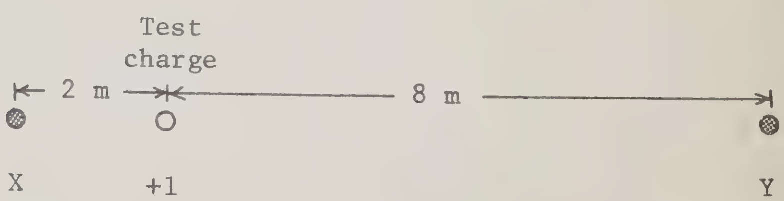
(A) 1:1

(B) 4:1

(C) 1:4

(D) 16:1

(E) 1:16



10

S17C
IV.1.b

92

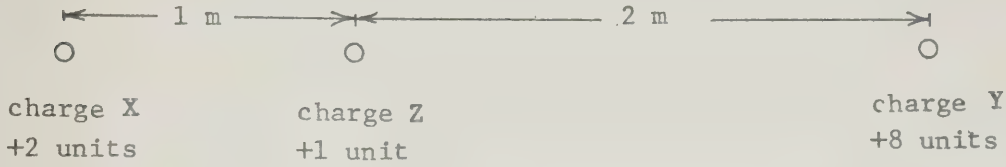
F1

(A)

-

**

The charges X, Y and Z are arranged as shown below.



The ratio of the magnitude of the electrical force of X on Z to the electrical force of Y on Z is

(A) 1:1

(B) 1:4

(C) 2:1

(D) 16:1

(E) 4:1

11

S17C
IV.1.b

92

F1

(E)

-

**

Three identical point charges, X, Y and Z are located at the vertices of a triangle as shown. If the force exerted by X on Y is *F*, and the force exerted by Z on Y is also *F*, what is the resultant force on Y?

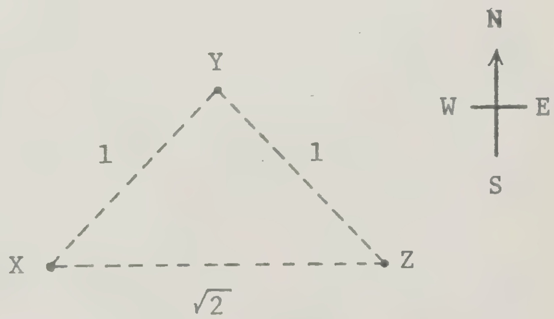
(A) 2 *F* [S]

(B) 2 *F* [N]

(C) $\sqrt{3}$ *F* [N]

(D) $\sqrt{2}$ *F* [S]

(E) $\sqrt{2}$ *F* [N]



ELECTRIC FIELD AND POTENTIAL

1 The electric field at a point near a charge Q represents

S17C
IV.1.c (A) the energy possessed by a unit positive charge

93 (B) the force acting on a unit positive charge

A2 (C) the energy possessed by a unit negative charge

(B) (D) the force acting on a unit negative charge

\- (E) the amount of work which could be done by a unit positive charge

**

2

S17C
IV.1.c

94

A4

(B)

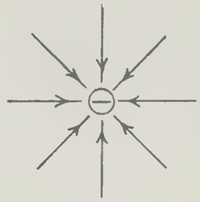
**

\-

Which of the following diagrams most accurately represents the electric force field about a small isolated negatively charged sphere?

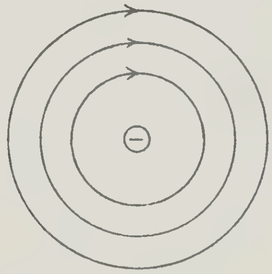
(A)

(B)

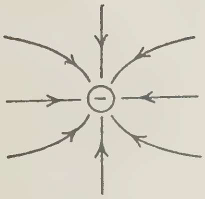


(C)

(D)



(E)



3 Which of the following diagrams most correctly describes the electric field in the vicinity of two small isolated oppositely charged spheres?

S17C
IV.1.c

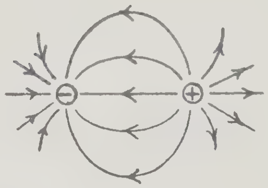
94

A11

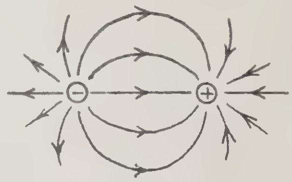
(A)

**
-

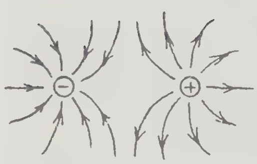
(A)



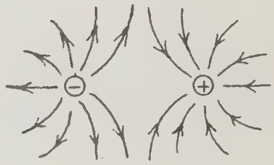
(B)



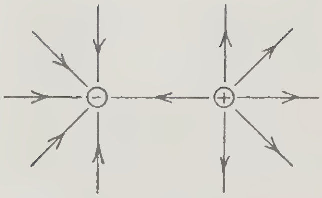
(C)



(D)



(E)



4

S17C
IV.1.c

94

F1

(D)

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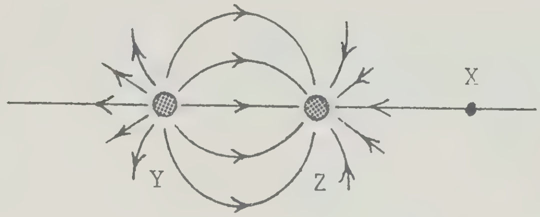
-

The diagram shows the electric field lines in a region of space containing two small charged spheres, Y and Z.



Which of the following statements is true?

(A) The charge on Y is negative and the charge on Z is positive.

(B) The strength of the electric field is the same everywhere.

(C) The electric field is strongest midway between Y and Z.

(D) A small negatively-charged object placed at X would tend to move toward the right.

(E) Both charged spheres Y and Z carry the same type of charge.

5 Which of the following diagrams most accurately describes the electric field in the region between two oppositely charged plates, X and Y.

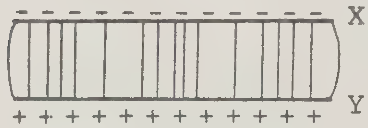
S17C
IV.1.c

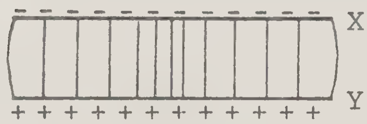
95

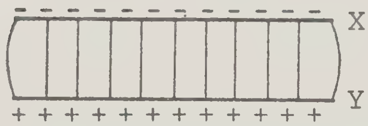
All

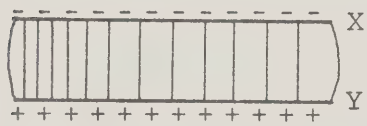
(C)

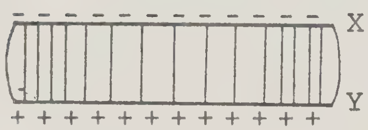
**
-

(A)


(B)


(C)


(D)


(E)


CURRENT ELECTRICITY AND ELECTROMAGNETISM

1

S17A
III.2.b

S 101

A7

(A)

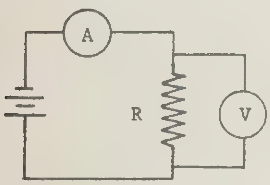
**

-

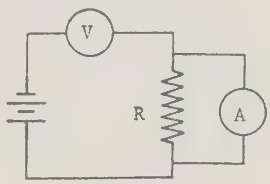
In the following circuits an ammeter (A), a voltmeter (V), a resistor (R) and a battery are shown. It is desired to measure the current passing through the resistor and the potential difference across it.

In which one of the following circuits are the instruments connected correctly?

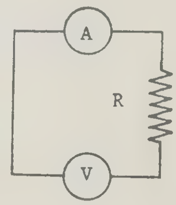
(A)



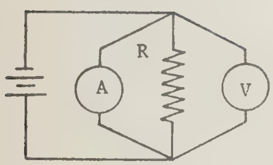
(B)



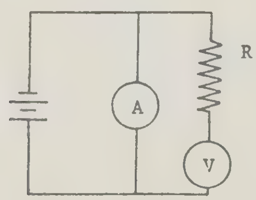
(C)



(D)



(E)



2 Consider the following circuit diagram.

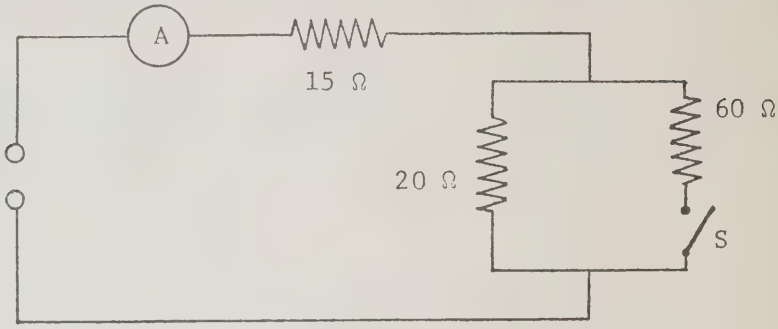
S17A
III.2.g

104

F1

(C)

**
-



When the switch S is open, the reading on the ammeter is 2.0 A. The potential difference across the D.C. source is equal to

(A) 30 V

(B) 60 V

(C) 70 V

(D) 110 V

(E) 190 V

3

S17A
III.2.g

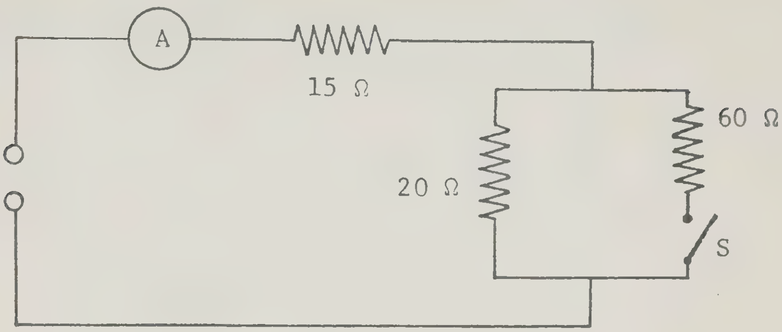
104

A5
F1

(A)

***

Consider the following circuit diagram.



When the switch S is open, the reading on the ammeter is 2.0 A. When the switch is closed, the reading on the ammeter would

(A) increase slightly

(B) remain the same

(C) decrease slightly

(D) double

(E) halve

4 Consider the following circuit diagram.

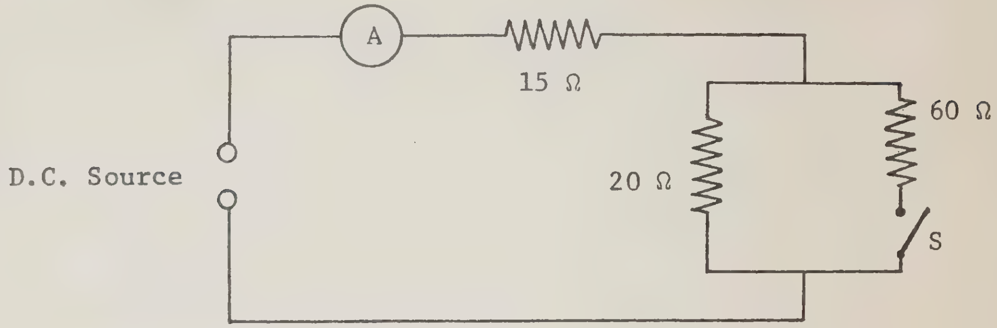
S17A
III.2.g

104

F1

(B)

**
-



With the switch S closed, the total effective resistance in the circuit is

(A) 7.5 Ω

(B) 30 Ω

(C) 35 Ω

(D) 55 Ω

(E) 95 Ω

5 Your family decides to charge you 4.0¢/(kW·h) for watching programs on television. If the television set is rated at 125 W, how long can you watch for 5.0¢?

S17A
III.2.h

106

F1

(E)

**
-

(A) 0.010 h

(B) 0.10 h

(C) 0.16 h

(D) 2.5 h

(E) 10 h

6

S17A
III.3.k

108
109

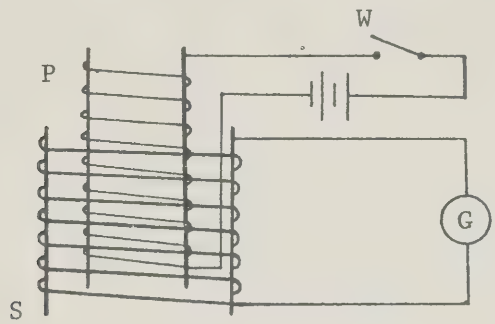
B1
A3

(D)

*

-

In the diagram below, the primary coil P is connected to a power supply and a switch W. The secondary coil S is connected to a galvanometer G. The primary coil is held stationary inside the secondary coil.



The following steps are performed:

I. The switch is closing to connect the circuit.

II. The switch is held closed.

III. The switch is opening to disconnect the circuit.

IV. The switch is held open.

During which of these steps does G show a steady zero reading?

(A) I only

(B) II only

(C) II and III only

(D) II and IV only

(E) I and III only

ELECTROMAGNETIC SPECTRUM

1

S17C
IV.4.a
110
A5
(E)
-
***

In which one of the choices listed below are the three types of radiation correctly placed in order of increasing frequency?

(A) Gamma rays, radio waves, infrared radiation.

(B) Radio waves, gamma rays, infrared radiation.

(C) Infrared radiation, radio waves, gamma rays.

(D) Gamma rays, infrared radiation, radio waves.

(E) Radio waves, infrared radiation, gamma rays.

2

S17C
IV.4.a
110
A5
(B)
-
*

The following types of electromagnetic radiation are listed from A to E in order of increasing frequency, with one type of radiation out of place. Which one is out of place?

(A) radio waves

(B) X-rays

(C) infrared radiation

(D) green light

(E) gamma rays

3

S17C
IV.4.b
111
A1
(E)
***
*

Which of the following types of electromagnetic radiation travels at the greatest speed in a vacuum?

(A) radio waves

(B) visible light

(C) X-rays

(D) gamma rays

(E) all of the above travel at the same speed

WAVE/PARTICLE DUALITY

OF

ELECTROMAGNETIC

RADIATION AND MATTER

PHOTONS

1 When violet light is beamed onto the negative electrode in a phototube, a current begins to flow in the tube.
S17C Consider the following forms of electromagnetic
IV.6.c radiation.

i16 I. blue light

A3 II. infrared radiation

(C) III. ultraviolet radiation

\- Which of these must also cause a current to flow in the
** tube, provided all other conditions remain the same?

(A) I only

(B) II only

(C) III only

(D) II and III only

(E) none of the above

2

S17C
IV.6.a
II.1
II.6

116
87
74

E4

(C)

-

***

Suppose that an experimenter has produced a new type of 'photographic' film which is sensitive to radio waves. He intends to design a camera which will produce radio 'photographs'.

Which one of the following characteristics of electromagnetic radiation supports the claim that the proposed camera is unlikely to produce sharp images?

(A) Electromagnetic waves change speed on passing from one medium to another.

(B) Electromagnetic waves appear to transport energy in packets (photons), and the energy carried by each packet is proportional to the frequency of the wave.

(C) Electromagnetic waves exhibit diffraction in amounts directly proportional to their wavelength.

(D) Nearly all non-metallic matter is transparent to electromagnetic waves of very long and very short wavelength.

(E) Electromagnetic waves of different wavelengths travel at the same speed in empty space.

3

S17C
IV.6.c

116

A5
A3

(D)

-

**

In the photoelectric effect, increasing the frequency of the light incident on a metal surface

(A) decreases the threshold frequency for the emission of photoelectrons

(B) decreases the number of photoelectrons emitted

(C) increases the threshold frequency for the emission of photoelectrons

(D) increases the kinetic energy of the most energetic photoelectrons

(E) does not affect the kinetic energy of the photoelectrons

4

S17C
IV.6.c

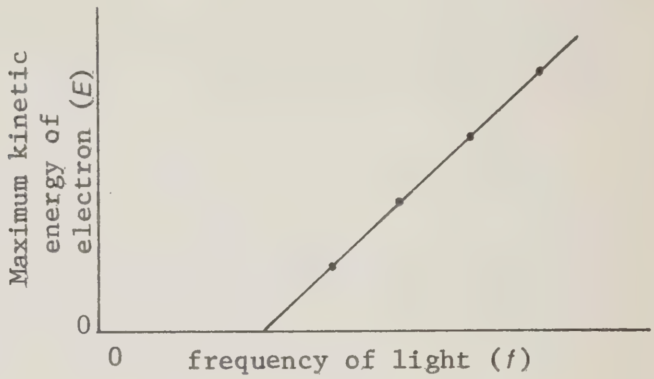
116

A8
F1
E4

(B)

–
**

The graph represents the results of an experiment in which light falls on a metal surface. The kinetic energy of the most energetic electrons emitted (E) is plotted against the frequency of the light (f).



Here are three suggested changes in the experimental conditions:

I. Use light with a wavelength shorter than any used above.

II. Use light of the same wavelength but of greater intensity.

III. Use a metal surface with a different work function (or threshold energy).

For which of the above changes would the readings fall on the original straight line or its extension?

(A) I only

(B) I and II only

(C) I and III only

(D) II and III only

(E) I, II and III

5

S17C
IV.6.c

116

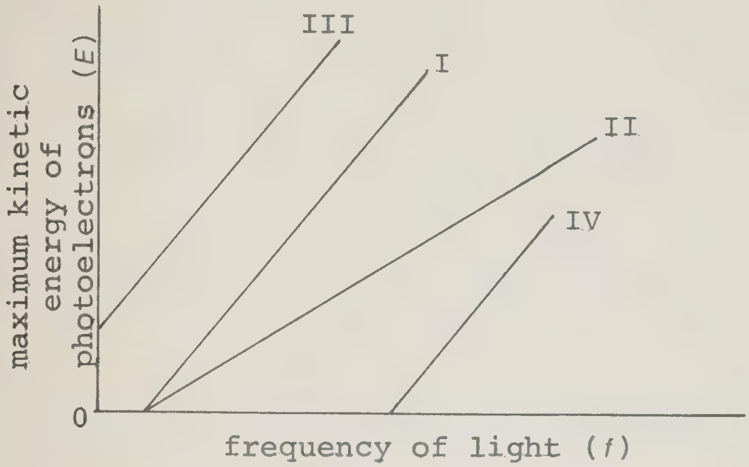
A 11

(C)

-

***

The graphs below are supposed to show the maximum kinetic energy of photoelectrons (*E*) ejected from the surface of four different metals by various frequencies of light (*f*).



If graph I is known to be correct for one metallic surface, which of the other graphs could be correct for the other metallic surfaces?

(A) II only

(B) III only

(C) IV only

(D) III and IV only

(E) II and IV only

6 Suppose that an experimenter has produced a new type of 'photographic' film which is sensitive to radio
S17C waves. He intends to design a camera which will
IV.6 produce radio 'photographs'.
S17C
II.1 Which one of the following characteristics supports
S17C the claim that the new film will probably be sensitive
II.6 to light?

116 (A) Electromagnetic waves change speed on passing from
87 one medium to another.
74

(B) Electromagnetic waves appear to transport energy
E4 in packets (photons), and the energy carried by each packet is proportional to the frequency of
(B) the wave.

– (C) Electromagnetic waves exhibit diffraction in amounts directly proportional to their wavelength.

***

(D) Nearly all non-metallic matter is transparent to electromagnetic waves of very long and very short wavelength.

(E) Electromagnetic waves of different wavelengths travel at the same speed in empty space.

7

S17C
IV.6.c

116

A9

(E)

-

***

The photon model of light was proposed to account for several observations of the behaviour of light. Consider the following statements.

I. A photon has a definite wavelength.

II. A photon has a definite energy.

III. A photon has a definite momentum.

Which of the above statements is/are postulates of this model?

(A) II only

(B) I and II only

(C) I and III only

(D) II and III only

(E) I, II and III

8

S17C
IV.6.d

117

A1

(B)

-

**

If the charge on one electron is 1.6×10^{-19} C, then one electron volt is

(A) 1.6×10^{-19} C

(B) 1.6×10^{-19} J

(C) 1.6×10^{-19} N

(D) 6.2×10^{18} C

(E) 6.2×10^{18} J

9

S17C
IV.6.c

118

A3
F1

(E)

-

***

The maximum kinetic energy of the most energetic photo-electrons ejected from the surface of the metal lithium by a certain colour of light is 3.8 eV. The threshold energy of lithium is 2.5 eV. What is the energy of a photon of this colour of light?

(A) 1.3 eV

(B) 2.5 eV

(C) 3.2 eV

(D) 3.8 eV

(E) 6.3 eV

10

S17C
IV.6.c

118

F1

(A)

-

**

A given source produces light having a wavelength of 5.0×10^{-7} m. Given that $h = 4.1 \times 10^{-15}$ eV·s, what is the energy carried away by one photon from this light source?

(A) 2.5 eV

(B) 0.40 eV

(C) 2.1×10^{-21} eV

(D) 6.8×10^{-30} eV

(E) 8.2×10^{-9} eV

THE ATOM

THE RUTHERFORD MODEL

1

S17A
IV.2.d
S17C
IV.5.a

125

A1
I3

(C)

-

**

In a Rutherford scattering experiment, particles are beamed at a piece of thin gold foil. Which one of the following statements best describes the initial observations?

(A) The particles are uniformly scattered in all directions.

(B) Most of the particles are scattered backwards.

(C) Most of the particles pass through without appreciable deflection.

(D) Most of the particles are deflected through a large angle.

(E) Most of the particles are absorbed by the gold foil.

2

S17A
IV.2.d
S17C
IV.5.c

126

D3
I3

(C)

***
**

In the Rutherford "gold foil" experiment <u>most</u> of the bombarding particles pass through the foil <u>undeflected</u>. Which one of the following properties of the nucleus would best account for this observation?

(A) The nucleus has a positive charge.

(B) The nucleus contains most of the mass of the atom.

(C) The nucleus is small in size compared to the rest of the atom.

(D) The nucleus has a very small mass.

(E) The nucleus contains both neutrons and protons.

3

S17A
IV.2.d
S17C
IV.5.c

126

A9
I3

(C)

***
**

Rutherford devised a model for the structure of atoms based on the results of his famous scattering experiment. Which of the following statements is <u>not</u> a feature of the Rutherford model of the atom.

(A) The atom is mostly empty space.

(B) The atom contains a relatively massive central core called the nucleus.

(C) Electrons are associated with definite energy levels.

(D) Electrons revolve about the nucleus and are held in orbit by the Coulomb attraction.

(E) The nucleus carries enough positive charge to make the whole atom electrically neutral.

4

S17A
IV.2.e

S 126

F1
A8

(D)

-

***

A solution was prepared by adding 5.0 cm^3 of pure oleic acid to 995 cm^3 of alcohol. To make up a volume of 1.0 cm^3 required 28 drops of the solution. One drop of this solution was observed to spread out on a water surface to an average diameter of 22 cm.

The maximum dimension of a molecule of oleic acid is

(A) $\dfrac{28 \times 10^{-3} \times \pi \times 11^2}{5.0}$ cm

(B) not obtainable from these data

(C) $\dfrac{5.0 \times \pi \times 11^2}{995}$ cm

(D) $\dfrac{5.0 \times 10^{-3}}{28 \times \pi \times 11^2}$ cm

(E) $\dfrac{5.0 \times 11^2}{1000 \times \pi}$ cm

ENERGY LEVELS

1 Consider the following statements.

S17C
IV.8.a
128
A3
(B)
-
***

I. Electrons orbiting a nucleus have characteristic wavelengths.

II. An atom can absorb only discrete amounts of energy.

III. An electron can absorb only discrete amounts of energy.

For which of the above statements did the Franck-Hertz experiment provide evidence?

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) I and III only

2

S17C
IV.8.a

129

F1
A9

(D)

-

**

In an experiment similar to that carried out by Franck and Hertz, atoms of element "A" are bombarded with electrons of various energies. The experiment was then repeated using atoms of element "B" as targets.

The following statements are made about these two experiments.

I. In both experiments, the electrons lost only discrete amounts of energy.

II. Electrons interacting with atoms of element "A" lost the same amount of energy as electrons interacting with atoms of element "B".

III. Such experiments could be used to demonstrate that different atoms have their own unique set of energy levels.

Which of the above statement(s) is/are true?

(A) I only

(B) II only

(C) I and II only

(D) I and III only

(E) II and III only

3

S17C
IV.8.c

128

D1
F1

(D)

-

**

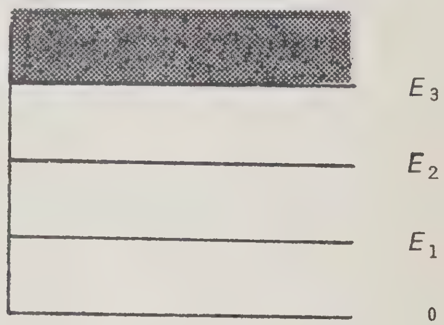
When a gaseous sample of an element was bombarded by electrons of different kinetic energies, the following observations were made.

I. Electrons with kinetic energies of less than 1.3 eV collided elastically with the atoms of the gas.

II. Electrons with a kinetic energy of 1.7 eV rebounded from the atoms with 0.4 eV.

III. Electrons with a kinetic energy of 4.6 eV rebounded from the atoms with either 2.1 eV or 3.3 eV.

The energy level diagram for the atom is shown below. (Not drawn to scale.)



Based on this information, which one of the following pairs of values is most likely for energy levels, E_1 and E_2?

(A) E_1 = 0.4 eV E_2 = 1.3 eV

(B) E_1 = 1.3 eV E_2 = 1.7 eV

(C) E_1 = 1.3 eV E_2 = 2.1 eV

(D) E_1 = 1.3 eV E_2 = 2.5 eV

(E) E_1 = 1.7 eV E_2 = 2.5 eV

4

S17C
IV.8.b
129
A3
(E)
-
**

An electron of kinetic energy 15.3 eV collides with an atom having an ionization energy of 12.1 eV.

Consider the following quantities of energy.

I. 3.2 eV

II. 12.1 eV

III. 15.3 eV

If the atom is ionized on impact, with which of the above energies would it be <u>impossible</u> for the electron to rebound?

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) II and III only

5

S17C
IV.8.c
129
A11
F1
(D)
-
**

The diagram illustrates the energy levels of the atom of metallic element X in a gaseous state.

An electron with kinetic energy of 12.0 eV collides with an atom of X. With which one of the following energies could it rebound?

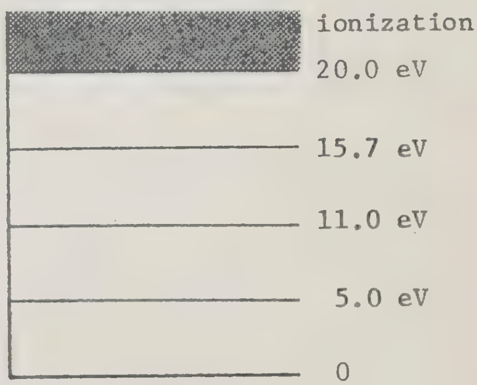
(A) 0

(B) 3.7 eV

(C) 5.0 eV

(D) 7.0 eV

(E) 8.0 eV



6

S17C
IV.8.d

131

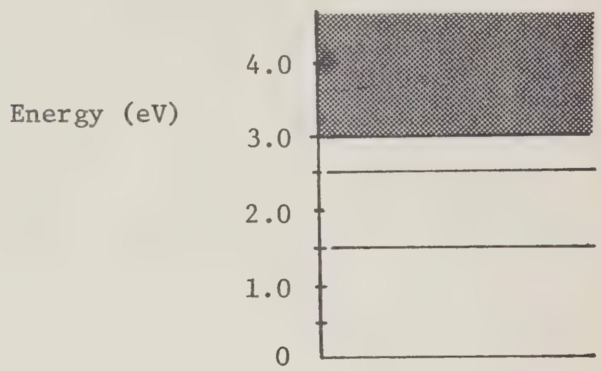
A3
A4

(D)

–

***

The complete energy level diagram for a hypothetical atom is given below. The radiation emitted from a gaseous sample of these atoms in an excited state will show several spectral lines.



Which one of the following spectral energies will not be represented by a line in the spectrum?

(A) 0.5 eV

(B) 1.0 eV

(C) 1.5 eV

(D) 2.0 eV

(E) 2.5 eV

7

S17C
IV.8.e

132

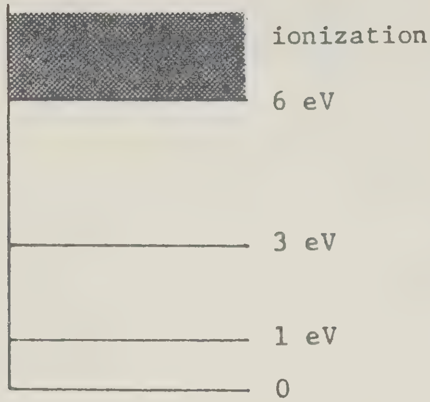
A3
F1

(B)

-

***

The diagram shows the energy levels of a hypothetical atom.



An 8 eV photon strikes the atom. Which of the following events could occur?

(A) The photon is absorbed and an electron with 8 eV of kinetic energy is ejected.

(B) The photon is absorbed and an electron with 2 eV of kinetic energy is ejected.

(C) The atom is raised to the 1 eV energy level and an electron with 7 eV of kinetic energy is ejected.

(D) The photon is absorbed and an electron with 6 eV of kinetic energy is ejected.

(E) The atom is ionized and the photon recoils with 2 eV of energy

8

S17C
IV.8.c

132

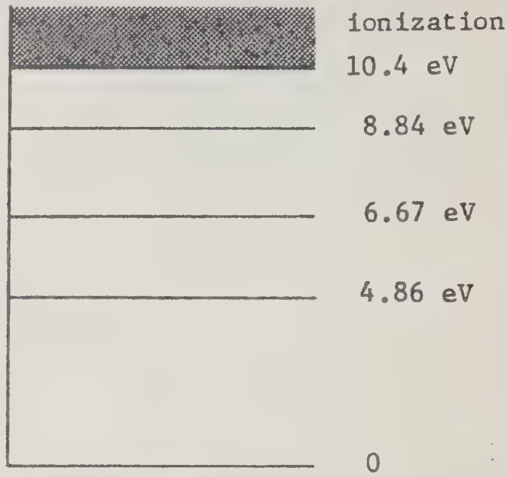
A9
F1

(D)

-

**

The energy level diagram for the mercury atom is shown below.



An electron with an energy of 9.0 eV collides with a mercury atom which is in the ground state.

The mercury atom could

(A) be excited to the 8.84 eV energy level only

(B) be excited to an energy of 1.4 eV only

(C) be excited to an energy of 0.16 eV only

(D) be excited to any one of the 4.86 eV, 6.67 eV or 8.84 eV energy levels

(E) not be excited by this electron

9

S17C
IV.8.e

132

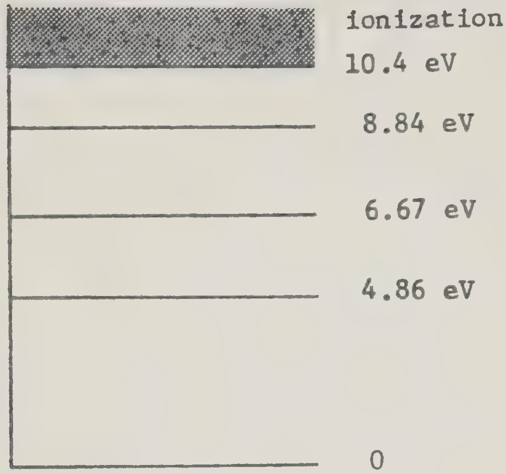
A9
F1

(E)

-

***

The energy level diagram for the mercury atom is shown below.



A photon with an energy of 9.0 eV collides with a mercury atom which is in the ground state.

The mercury atom could

(A) be excited to the 8.84 eV energy level only

(B) be excited to an energy of 1.4 eV only

(C) be excited to an energy of 0.16 eV only

(D) be excited to any one of the 4.86 eV, 6.67 eV or 8.84 eV energy levels

(E) not be excited by this photon

NUCLEAR ENERGY

1 An isotope of the element manganese has an atomic number of 25 and a mass number of 55. The nucleus of a manganese atom contains

S17A
IV.2.f

135

F1

(A)

*
-

(A) 25 protons and 30 neutrons

(B) 30 protons and 25 neutrons

(C) 25 protons and 55 neutrons

(D) 25 protons and 25 neutrons

(E) 55 protons and 25 neutrons

2 The alpha particle consists of

S17A
IV.3.a

138

A2

(C)

**
***

(A) 1 proton and 1 neutron

(B) 1 proton and 2 neutrons

(C) 2 protons and 2 neutrons

(D) 2 protons and 4 neutrons

(E) 2 protons, 2 neutrons, and 2 electrons

3 A particle was emitted from the nucleus of an atom and it was found that the atomic number of the atom increased. The emitted particle was probably

S17A
IV.3.a

138

A5

(A)

*
***

(A) a beta particle

(B) an alpha particle

(C) a proton

(D) a positron

(E) a neutron

4

S17A
IV.3.a

142

F1

(B)

*

–

Which nucleus represents the missing term in the following nuclear fission reaction?

$$^{236}_{92}U \rightarrow ^{90}_{38}Sr + \_\_\_\_\_ + 3^{1}_{0}n + \text{Energy}$$

(A) $^{145}_{54}Xe$

(B) $^{143}_{54}Xe$

(C) $^{145}_{55}Ba$

(D) $^{43}_{51}Sb$

(E) $^{145}_{51}Sb$